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Considering COTS

Carol Booth

Introduction

In recent years, the Department of Defense (DoD) has placed increasing emphasis on the use of commercial off-the-shelf (COTS) items. Some have seen the use of COTS as the *silver bullet* that will allow the Services to deploy more capable systems faster and at lower cost. Others have viewed the use of COTS items more skeptically. Many in this latter group believe that COTS cannot work effectively in military systems and that this is just the latest *snake oil.* This article suggests there is a middle ground while exploring some of the issues related to the use of COTS items in military applications.

Background

The military has always used COTS items. Examples include test equipment, staff cars, office equipment, engines for transport aircraft and construction equipment where the military use and operational environment were similar to civilian applications. Since the mid-1980s, there has been an increasing push to expand the use of COTS applications. In 1986, Congress passed legislation requiring the DoD to consider the use of nondevelopmental items (NDI) prior to launching a development program. The Services responded to this legislation by encouraging consideration of COTS items.

In the 1990s, the end of the Cold War led to faster and more sweeping changes in the DoD. The military downsized and budgets declined, while mission requirements shifted to include more military operations other than war and became less predictable. In this environment, developing systems from the *ground up* using military specifications and standards is often not practical. In response, the DoD created Acquisition Reform (AR) initiatives intended to reduce cost and cycle time by applying commercial practices and leveraging the commercial industrial base. The Federal Acquisition Streamlining Act of 1994 and the Federal Acquisition Reform Act of 1996 broadened the definition of commercial items and made it easier to acquire COTS items and modified commercial items. This, together with the realization that leadership in key technologies had passed from the DoD to industry, has strengthened the move to use COTS items in weapon systems.

Characteristics

Effective use of COTS items requires an understanding of the nature of the commercial market. Three *facts of life* are:

- Technology is constantly changing.
- Market forces outweigh DoD needs.
- Vendors control configuration and data.

Rapidly advancing technology yields increasing performance and enhanced product features. Today, the technology cycle for semiconductors is less than two years.[1] Semiconductor availability drives the configuration of COTS circuit cards. The product support life cycle for electronics ranges from four to six years. Consequently, support plans for COTS items must include provisions to deal with the inevitable parts obsolescence.

The DoD is just another customer in the commercial market place. The DoD's share of the semiconductor market fell from 17 percent in 1975 to 1.3 percent in 1995.[2] Decisions to discontinue production of particular items are based on market forces and profit. Competing companies race to bring out new products with enhanced features/performance and reduce costs to gain market advantage. As these new products are introduced, older products with limited market share are discontinued. As a result, the DoD must learn to plan for market changes.

Vendors control the internal configuration of their products and all technical data. Availability and cost of components drive configuration changes. Product layout and packaging may be changed to gain manufacturing efficiencies or increase yield. A typical COTS single board computer may have hundreds of engineering changes each year. Customers are typically not notified of configuration changes and part numbers are generally not updated.[3] For example, the Q-70 Program received replacement circuit cards with a firmware revision and the program office was unaware of the change.[4] Vendors maintain product data geared to marketing and manufacturing needs. Design details are normally proprietary with only performance and interface data provided to customers. Data available to the DoD is the same as that available to other customers. Vendors determine the data format.

The biggest benefit of using COTS items is the ability to put more capability into the hands of the warfighter faster.

These COTS characteristics yield significant benefits, but also produce challenges.

Benefits

The biggest benefit of using COTS items is the ability to put more capability into the hands of the warfighter faster. This is particularly important as mission requirements become less predictable and as traditional acquisition cycles stretch to 15 years or more. With technology turning over every two years, the long cycle time required for military development virtually

guarantees systems will be obsolete before they are fielded. With COTS solutions, research and development activities are limited to market surveys, testing of sample items and integration activities; hardware production starts as soon as contracts are awarded. Figure 1[5] shows the impact of using COTS on development time.

Use of COTS items also reduces acquisition costs. Reduced requirements for research and development result in up-front cost savings. Economies of scale achieved by large-scale commercial production runs yield savings in procurement cost. Figure 1 also

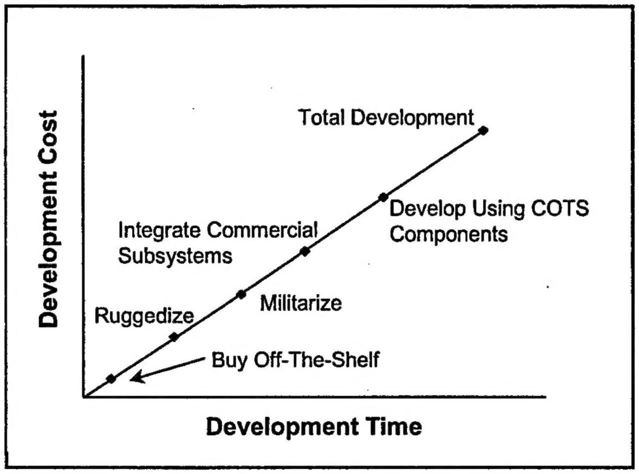

Figure 1. COTS Development Strategy, Cost Versus Time

shows the relationship between various COTS strategies and development cost. Using unmodified COTS items is the fastest and lowest cost strategy. The more modification required, the longer the cycle time and the higher the costs. But even development using COTS components, rather than custom designed, Military Specification (Mil-Spec) components can save significant time and money.

Many upgrade/modification programs have shown that replacement of aging military electronics with higher reliability COTS items reduces operating and support costs. The availability of a commercial support and repair infrastructure saves the cost of establishing military repair capability. Additionally, the overhead associated with these commercial support facilities is spread over the entire population of items supported, commercial as well as military. Vendors may also be driven to hold service costs down to gain market advantage. Replenishment items may be obtained from the vendor on a Just-In-Time (JIT) basis, saving inventory costs.

Use of COTS items reduces the technical risks. For COTS items with a large installed population, performance is well known. A small number of units can be procured for testing and commercial users can be surveyed for performance data. A two-step acquisition strategy where vendors are required to submit bid samples may also be used.

Challenges

There are three main areas where the use of COTS provides significant challenges and potential pitfalls:

- Integration and Interface.
- Military Suitability.
- Long-Term Affordability.

Integration and Interface

In many cases, COTS items do not perform a totally stand-alone function. Often the COTS items must interface or be integrated with other COTS or Mil-Spec items within a system.

Many upgrade/modification programs have shown that replacement of aging military electronics with higher reliability COTS items reduces operating and support costs.

Use of *open systems architectures* minimizes interface problems, but even here there are challenges. Standards developed by industry groups and professional associations are consensus based. Achieving the consensus needed to finalize a standard often takes years. In the meantime, technology moves forward. As a result, approved standards may not adequately address the capabilities provided by the technology available. Industry standards also tend to be less prescriptive than traditional military standards, providing multiple implementation options. Compliance with a standard usually indicates adherence to the core requirements, thus products can comply with the same standards and be quite different.

Vendors often include nonstandard features or *extensions* of the standard in COTS items to incorporate new technology not addressed by the standard and to distinguish products in the marketplace. When COTS items are selected for integration into a system, care should be taken to clearly understand which standard options are required and what non-standard features the selected items incorporate. One of the dangers with nonstandard features is that the system design can become dependent on these extras, limiting choices for replacement items when the original COTS components reach the end of their life. Further, there is no guarantee that products supporting any industry standard will continue to be available for the 20 or more years of a weapon system life cycle. The same can be said for *popular* standards, like Windows NT®. These standards depend on market acceptance. When standard products are no longer profitable, they will disappear from the market.

Another integration/interface challenge is mismatched life cycles. In systems composed of multiple COTS items, the various items are likely to have different upgrade cycles. This is particularly a problem with COTS software. Once the new version is released, it is usually impossible to buy additional copies of the older versions. While the new release is normally capable of reading files generated by the older versions, the old software is rarely capable of reading files generated with the new version. This forces update of otherwise fully operational software.

Evolution of COTS technology can also necessitate changes to Mil-Spec items and system software. When the original COTS components of a system reach the end of their commercial life, they are replaced with *new models*. These new models are usually better and faster. Often the higher speed causes system problems, if custom designed or legacy Mil-Spec components cannot handle the increase in performance.

Military Suitability

Military suitability defines the ability of the COTS item to perform satisfactorily in the operational environment over the long haul. Key elements of suitability are survivability and supportability.

Much of the traditional reluctance to use COTS items in weapon systems is based on the belief that COTS items cannot withstand the military environment. This is a valid concern. However, it is important to understand that many civilian operating environments are also severe. Environmental requirements should be viewed critically. Does the equipment need to operate in an environment where its operators could not function? What are the real temperature ranges the item might be exposed to?

Typically COTS items do not undergo the extreme shock, vibration and temperature testing required of Mil-Spec items. This testing is costly and, from the vendors perspective, the magnitude of potential military sales may not warrant the expense. However, COTS items may in fact be capable of withstanding the required shock, vibration and temperature. Sample items can be procured and tested as part of the selection process. Another approach to survivability issues is to provide protection for the COTS items. For example, COTS items can be housed in a rugged cabinet that dampens shock and vibration.

Supportability, the second key element of suitability, is another traditional area of concern with COTS items. There are very few military systems that do not require some level of organizational or intermediate level maintenance. With COTS items it is important to understand up front exactly the extent of maintenance that must be performed organically. Organic maintenance requirements will drive the supply support, configuration management and data requirements.

Often organic maintenance on COTS items is limited to removal and replacement of the entire COTS item. In some cases, major components (for example, circuit cards) may be removed and replaced. Lack of configuration control and detailed design data preclude effective piece part repair. This represents a real paradigm shift in the military maintenance community. It also means stocking more expensive modules rather than piece parts, thus increasing storage requirements and dependence on supply lines.

Since detailed design data for COTS items is proprietary, the military and the system integrators must rely on the Original Equipment Manufacturers (OEMs) for technical assistance and depot-level repairs. This makes sole source Contractor Logistics Support (CLS) a fact of life for COTS items. Leveraging the commercial repair infrastructure saves the nonrecurring cost of establishing organic depot capability and, when there is a large commercial repair market, can lower unit repair cost.

However, relying on CLS brings risks. When the commercial repair market is small, the lack of competition will drive up prices. There is also the question of timely availability of CLS to support emerging peacekeeping and humanitarian relief missions or in the event of hostilities. In the past, some contractors have provided on-site support in areas of conflict, but others have not. Longevity of support is another concern. Will the support be available for the duration of the equipment's life cycle? Companies go out of business, merge or move on to newer product lines. *Escrow* of data mitigates the risk of the OEM ending support prematurely. Successful use of this approach requires a mechanism to ensure the adequacy, accuracy and currency of the escrowed data.

Supply support for COTS items also brings some unique challenges. Since COTS items are deployed faster, less time is available for provisioning. Most OEMs do not provide standard military format provisioning data. Either the government or the system integrator must derive the necessary data from catalogs and specification sheets.

Continuing supply support is complicated by parts obsolescence. When the original part is no longer available, the inventory control activity must identify a substitute part. Analyses or tests will be required to ensure the substitute part will perform adequately in field. The ability of the part to function in the operational systems must be verified, as well as its ability to perform in the intended environment. In fact, even when procuring replenishment parts with the same part number, testing may be necessary to ensure function and interface compatibility. As noted earlier, vendors make frequent changes to the internal configuration of COTS items without changing part numbers. In some cases, changes may cause anomalies in system operation.

In addition, documentation provided for commercial users may not be adequate for military use. Commercial manuals inevitably require a military supplement. Also, commercial documentation comes in a wide variety of sizes and shapes. Dealing with dozens of commercial manuals in all different sizes and formats can place an undue burden on the operating forces. To avoid this, it is often necessary to rework the commercial documentation into a standard form, adding another cost.

Long-Term Affordability

Today the emphasis in the DoD is on Total Ownership Cost (TOC). TOC encompasses all the costs to research, develop, acquire, own, operate and dispose of weapon and support systems as well as the cost of military and civilian personnel and business operations of the DoD. It is important to view the use of COTS items from a TOC perspective. Some costs associated with use of COTS items may be difficult to link to specific weapon systems. For example, costs such as ongoing market surveillance to provide a knowledge base for identifying COTS products/technologies with military application and monitoring for parts obsolescence may not be directly linked to weapon systems. Also, costs of maintaining test beds for evaluation of candidate replacement items and testing replenishment items must also be considered. If these costs are included in overhead, the real cost of COTS will not be visible.

The traditional breakout of weapon system life cycle costs is

10 percent Research and Development (R&D), 30 percent Production and 60 percent Operating and Support (O&S).[6] Figure 2 shows this traditional breakout. It is significant to note that the largest area of savings for COTS is in R&D, traditionally the smallest component of life cycle cost.

The life cycle cost profile for COTS items is distinctly different from Mil-Spec items. The nature of COTS components tends to change the distribution of costs across the life cycle. COTS solutions require far less R&D and often lower initial procurement cost. But keeping up with evolving COTS technologies and the associated parts obsolescence adds cost. There are two ways of dealing with parts obsolescence, lifetime buys and technology refreshment.

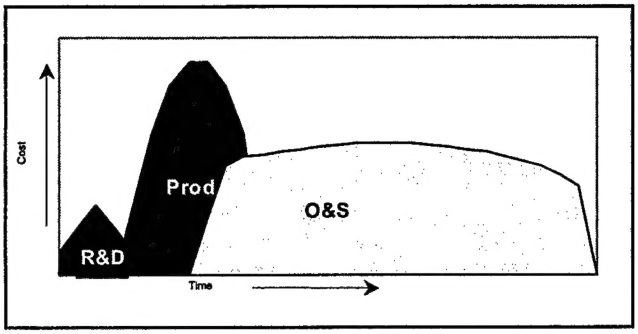

Figure 2. Typical Weapon System Life Cycle Cost Distribution

Using the lifetime buy strategy, all the replacement parts needed for the life of the weapon system are bought up front as part of the initial procurement. This increases initial procurement costs and inventory management costs. This strategy might yield a cost profile similar to the one shown in Figure 3. However, there are risks associated with the lifetime buy strategy. This strategy depends on the ability to accurately predict the lifetime spares requirement. These requirements, in turn, depend on the length of the systems' life cycle, item failure rates and system usage rates. Errors in estimating any of these factors can result in procuring too many or too few lifetime spares. Either is costly. A significant advantage of lifetime buys is that support resources (for example, technical manuals, supply data and training) remain constant.

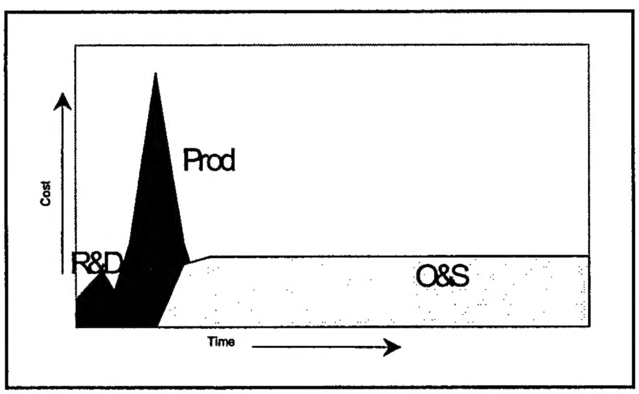

Figure 3. Cost Profile for Lifetime Buy

Technology refreshment involves replacing the COTS items periodically to keep up with evolving technology. Ideally, the technology refresh cycles are timed to avoid parts obsolescence. To reduce support risks, a commitment may be secured from the system integrator or OEM to support the COTS item for the duration of the refreshment cycle, or sufficient spares may be procured up-front to last through the refresh cycle. Depending on the technology involved, the refresh cycle may be as short as two or three years and as long as seven years. This strategy results in a cost profile similar to Figure 4. For each technology refresh cycle, some R&D is required to survey the commercial market, test and evaluate products, integrate the new COTS items and perform system tests. Updates to user documentation and training are also required. O&S costs remain low throughout. Technology refreshment has the added benefit of providing enhanced performance, although the enhanced performance can cause problems with the interface to legacy equipment.

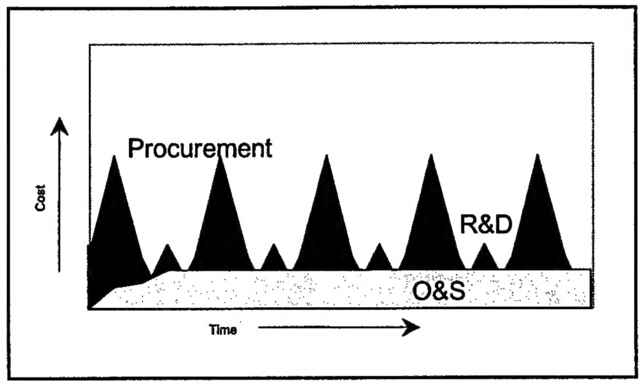

Figure 4. Life Cycle Cost Profile With Technology Refreshment

One significant risk associated with the technology refresh strategy is that the funds will not be available to implement the technology refresh on schedule. If the planned technology refreshment cannot be implemented, O&S costs will increase until obsolescent, non-supportable items can be replaced. This might result in a cost profile similar to Figure 5.

Alternately, technology refresh may be an ongoing activity rather than a series of periodic events. In this strategy, a sustaining engineering activity, either government or contractor, continuously monitors the commercial market for parts obsolescence and Diminishing Manufacturing Sources (DMS). Whenever a part is about to go off the market due to obsolescence or DMS, an analysis is performed to determine if a lifetime buy should made or if the part should be replaced. If a replacement strategy is selected, a market survey is conducted, items are evaluated and tested, the selected item is integrated into the system, operating and support documentation is updated and deployed systems are upgraded to the new configuration. The difference between this strategy and technology refreshment is that the cycles are less predictable and a core sustaining engineering function is maintained across the life cycle.

Considerations

Use of COTS items in weapon systems requires: careful analysis of the market place, technology trends and military requirements; consideration of alternate operation and

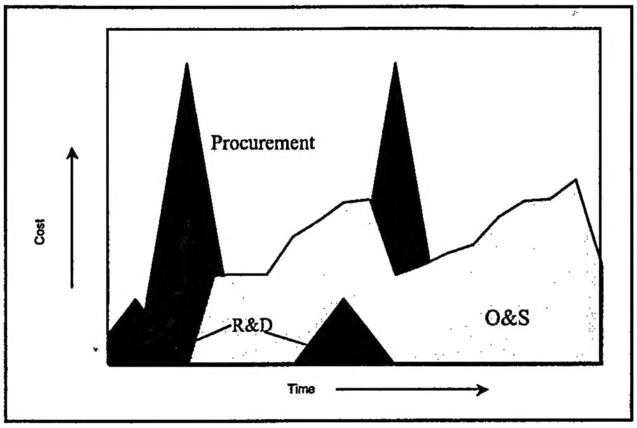

Figure 5. COTS Life Cycle Cost Profile With Delayed Technology Refresh

support concepts and their impact on the ability to meet mission requirements; attention to interface and integration issues; and comprehensive risk management strategy.

Understanding the market is critical. Is the market large or small? Are there many vendors supplying similar products or do one or two large suppliers dominate the market? How big a portion of the market is military? For some products, like rugged disk drives, military sales represent a large percentage of the market. For other products, like single board computers, military sales represent a very small part of the market. What is the *model cycle*, that is how often are new models introduced? Are interfaces standard across the industry?

Considering the nature of the underlying technology trends is essential. Is the technology stable or rapidly evolving? Today electronics technology generations average 18 months, while the technology base for mechanical equipment is much more stable. How is the technology evolving? Is backward compatibility likely with existing items? Is the technology for the COTS items being considered leading-edge, state-of-the-practice or lagging-edge?

Review requirements carefully. What must the item do? What is the operational environment? Overestimating the severity of the expected environment will unnecessarily eliminate many commercial items from consideration and increase costs. Underestimating the severity of the environment could prove to be even more costly if the item procured fails to perform in the field. How firm are the performance requirements?

Examination of support concept alternatives is required. What are the minimum organic maintenance tasks? Is replacement of the entire end item feasible for every failure mode? What is the impact on pipeline spares and transportation requirements? Generally, a maintenance concept based on removing and replacing relatively large system elements will reduce manpower requirements (numbers and skill level), but increase the cost of pipeline spares, transportation and asset visibility. Detailed iterative analyses are needed to assess the overall cost and readiness impact of various support alternatives. Consider how the proposed COTS item support fits with the existing support infrastructure.

Interfaces must be defined completely and comprehensively. Emphasize portability in software and test software on multiple COTS platforms whenever possible.

Most importantly, understand the risks. Conduct *worst case* analysis and prepare for contingencies.

Summary

Use of COTS items is now a necessity. COTS provides a cost-effective way to get new technology into the hands of the warfighter quickly. Long-term support issues remain, but, as with traditional development programs, careful planning up front will mitigate life cycle support problems.

Use of COTS items is now a necessity. COTS provides a cost-effective way to get new technology into the hands of the warfighter quickly.

Notes

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2. Ericson, Jeff, "Life Cycle Support for Military Systems—The Public Versus Private Debate," COTS/NDI Supportability Symposium, 10-12 Sep 96, NUWC Division, Keyport, WA.
3. Office of the Inspector General, "*Audit Report, Lessons Learned From Acquisition of Modified Commercial Items and Nondevelopmental Items*," Report No. 97-219, 23 Sep 97.
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5. Office of the Under Secretary of Defense for Acquisition and Technology, *SD-2, Buying Commercial & Nondevelopmental Items: A Handbook*, Apr 96.
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Ms. Booth is currently a Senior Staff Analyst with Dynamics Research Corporation. She has nearly 20 years of experience in logistics and related disciplines. In the course of her career, she has provided technical and management support for Army, Navy, Air Force and joint programs.

Measuring the Effect of Radio Frequency Identification Technology (RFID) on Movement of US Army Resupply Cargo

Captain Leigh E. Method, USAF

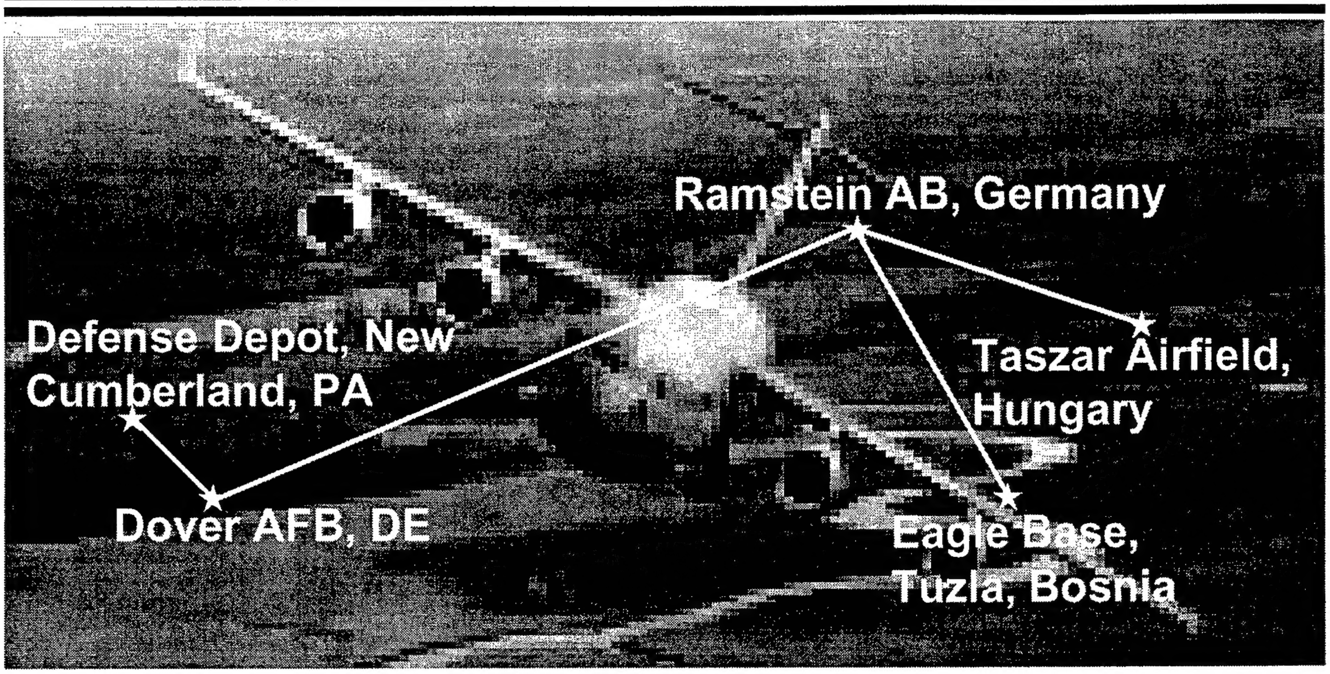

Figure 1. Routing of Army RFID-tagged Resupply Cargo Shipments

Introduction

From the moment a military unit places a requisition for parts or supplies into the supply system, two things about the shipment—the status and expected arrival date—are of interest to the end-user. With the proliferation of computers, information systems, the Internet and information technology applications such as bar code readers, the visibility of this information is now possible. A powerful way for customers to gain logistics information about their requisitions currently exists on the World Wide Web (WWW)—the Global Transportation Network (GTN). Now an end-user of an expected part or resupply item, located in an austere environment with only a laptop, can *uplink* or connect with an orbiting satellite and log-on to the Internet and the GTN web site. Once connected, the GTN web site provides detailed status and movement information as a shipment moves through the Defense Transportation System (DTS). This is the idea of in-transit visibility (ITV)—visibility of an item, person or unit en route from origin to destination during peace, contingencies and war.[1]

The US Army is moving cargo through the DTS[2] from the Defense Depot at New Cumberland, Pennsylvania, to the Bosnia-Herzegovina theater of operations using Radio Frequency Identification (RFID) technology. RFID technology involves a series of electronic tags (attached to the desired item and containing shipping/content information), interrogators (located at key nodes along the route of travel) and a computer-based system to collect the movement information. Shipping information is recorded on the tag at the shipment's origin and may be read by stationary or handheld interrogators using radio frequency energy to activate the tags and transmit information. Once identified by an interrogator, a date and time stamp is recorded and uploaded to an Internet server and a hosted web site where it is added to previously collected information.

RFID technology involves a series of electronic tags (attached to the desired item and containing shipping/content information), interrogators (located at key nodes along the route of travel) and a computer-based system to collect the movement information.

The purpose of this research was to investigate the Army's use

of Internet-based RFID technology for ITV and determine whether there is a difference in cycle time for resources moving through the Air Mobility Command (AMC)[3] portion of the DTS. The goal was to evaluate the contribution that Internet-based visibility of high-priority cargo associated with the application of RFID technology can make to total cycle time relative to non-RFID-tagged cargo. The hypothesis of this research was that the visibility of *tagged* items speeds the flow of resources in comparison to *non-tagged* items as they move through the AMC system—from the aerial port of embarkation (APOE) to the aerial port of debarkation (APOD).

Background

Although the implementation of various Information Technology (IT) applications is known to contribute to ITV, there has been no attempt to quantify the contribution these technologies make in terms of shipment cycle time between the requisition source and the end-user.

In-transit visibility (ITV) is defined by USTRANSCOM as the "ability to track the identity, status, and location of . . . cargo and passengers . . . from origin to the consignee or destination . . . during peace, contingencies, and war."[4] ITV of resupply (sustainment) materiel for forward-operating units is one of the most frustrating problems for logisticians in the field. A significant problem logisticians had to wrestle with during DESERT SHIELD/DESERT STORM (DS/DS) was the inability to effectively deal with the arrival of thousands of shipping containers with little or no idea about what was in them. In fact, during DS/DS, of the 40,000 containers of military materiel entering the theater, approximately 50 percent of them had to be opened, inventoried and reinserted into the transportation system because military personnel did not know their contents.[5] The Center for Army Lessons Learned cited three main reasons for these accountability and visibility problems. Specifically, containers packed at US depots lacked an adequate description of container contents, they arrived in Southwest Asia faster than the logistics system could process them and there were no procedures to document arriving containers designated for specific units.[6]

A recent General Accounting Office (GAO) report was critical of the federal government's inability to "properly account for and report billions of dollars of property, equipment, materials, and supplies."[7] The report noted that "certain recorded military property had, in fact, been sold or disposed of in prior years—or could not be located—and an estimated $9B of known military operating materiel and supplies were not reported."[8] The report also criticized the Pentagon for being uncertain about how much inventory was in-transit and the government's ability to "prevent unnecessary storage and maintenance costs or purchase of assets already on hand."[9]

Recently, the DoD, through United States Army Europe (USAREUR) developed a transportation pipeline that uses RFID technology to track supplies from the Defense Depot, New Cumberland, Pennsylvania, to Taszar, Hungary, and Tuzla, Bosnia, in support of OPERATION JOINT ENDEAVOR (OJE)[10] and OPERATION JOINT GUARD (OJG) (see Figure 1). These containerized or palletized shipments are tracked by attaching RFID tags to the cargo. These tags provide information to a system of interrogators stationed along the route of travel that transmit information through a portable control system into a database. Individual users are able to query this system via an Internet web site.

Although the implementation of various Information Technology (IT) applications is known to contribute to ITV, there has been no attempt to quantify the contribution these technologies make in terms of shipment cycle time between the requisition source and the end-user. Since there is some perception in the DoD that "ongoing transportation initiatives, such as ITV, will [result in] . . . reducing logistics response time by improving transit times,"[11] this study was aimed at comparing the movement of a set of RFID-tagged shipments to a set of non-RFID-tagged shipments as well as a set of DoD standards in an attempt to examine RFID technology's contribution to ITV and cycle time.

Total Asset Visibility (TAV) and In-Transit Visibility (ITV)

During DS/DS, units awaiting supplies had only a limited ability to trace their shipments. Concluding this situation was unacceptable, the DoD developed a *Total Asset Visibility Plan* that identified three categories of assets: in-storage, in-transit and in-process. Visibility over the status and location of these assets is known as Total Asset Visibility (TAV). The advent of Army Total Asset Visibility (ATAV) and, subsequently, Joint Total Asset Visibility (JTAV), provided a forum for testing emerging technologies such as RFID.

The DoD defines TAV as:

> . . . the capability that permits operational and logistics managers to determine and act on timely and accurate information about the location, quantity, condition, movement and status of Defense material. It includes assets that are in-storage, in-process and in-transit.[12]

Several significant DoD publications have highlighted the need for effective ITV. *Joint Vision 2010*, a conceptual template for the development of the US Armed Forces, discusses four new operational concepts: dominant maneuver, precision engagement, full dimensional protection and focused logistics.[13] In order to optimize the first three concepts, focused logistics must integrate

> . . . information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level of operations.[14]

The 1998 Air Mobility Master Plan (AMMP) considered achieving ITV the "single most challenging task" for USTRANSCOM[15] and one of AMC's top five modernization priorities.[16]

In the 1996 Annual Report to the President and the Congress, the Office of the Secretary of Defense (OSD) identified "visibility of material in storage and transit and rapidly transporting stocks between theaters" as essential to the National Security Strategy of winning "two nearly simultaneous major regional conflicts."[17] Furthermore, TAV would enable managers to "offset wholesale procurements with excess retail assets . . . increase user confidence, reduce duplicate requisitions, and expose supply and transportation system bottlenecks."[18] The 1998 DoD Logistics Strategic Plan reiterates this through the objective of "full fielding of identified TAV capabilities"—targeting 90 percent implementation by February 2000 with 100 percent capability by February 2004.[19]

The Internet and Information Technology

The private-sector logistics industry has always been very competitive and the use of the Internet for IT applications is a way many companies in the commercial sector are competing. Deregulation of the transportation industry in the 1970s and 1980s opened up commercial industry for investment in emerging technologies as a way to achieve market dominance. The past desire to manage shipment information and achieve visibility over the entire supply chain is now a necessity. Emerging information technologies such as RFID, bar-coding, electronic data interchange, electronic commerce and the Internet are some of the means firms have to compete in an increasingly information-based marketplace.

The Internet provides a host of utilities for gathering and communicating information about a shipment. Some of these utilities are electronic mail, *listservs* (electronic discussion groups) and the WWW. The Internet has even been called the sixth form of transportation.[20] Using the Internet, government and businesses can conduct their operations faster, cheaper and easier than with the more traditional forms of communication—telephone calls, mail and express delivery. Shippers, carriers and customers now have the ability to track the movement of their shipments as well as know the exact contents of a box or container.

Use of the Internet and IT applications has exploded in the commercial sector for logistics functions—in some cases, information is more important than the shipment itself. Not surprisingly, customers want fast materiel delivery and information on-demand for their shipments. In turn, this makes the use of IT for logistics companies "more strategic and critical than ever."[21]

One of the first companies in the Internet-based shipment-tracking business was Federal Express (FedEx). FedEx launched its Internet web site[22] in November 1994 and connected to millions of potential customers. Then, in 1996, it introduced *interNetShip*SM—the first automated shipping transaction utility available on the Internet.[23] InterNetShipSM software allows customers to complete electronic airbills, print shipping labels, request courier pickups and e-mail shipment status to other parties.[24]

The DoD should be able to reap the benefits of IT in both reduced inventories and the ability to centralize decision-making. The Internet provides a robust platform for organizations or individuals seeking information, all while being relatively inexpensive.[25] RFID and satellite-tracking are two technologies that are being *web-enabled* (linked to the Internet) to provide managers real-time shipping information. This information, in turn, allows for rapid decision-making when alternatives are needed.

Radio Frequency Identification (RFID)

RFID is one form of IT in use by the DoD. It is the concept of "automatically identifying, categorizing, and locating people and assets over relatively short distances (a few inches to hundreds of feet)."[26]

RFID is one form of IT in use by the DoD. It is the concept of "automatically identifying, categorizing, and locating people and assets over relatively short distances (a few inches to hundreds of feet)."[26] Assets are *tagged* with a *transponder* containing information about the item of interest and depending on the type of tag, various *read* and *write* capabilities are possible. The transponder communicates with an *interrogator* using radio frequency (RF) energy and the interrogators are linked to provide seamless coverage for a given system—or supply chain.

RFID tags are being used on vehicles, trucks and other materiel handling equipment in order to track their location, weigh them or even to debit the owner's account when they pass a *toll booth.* RF technology can also provide drivers with new instructions and priorities on a real-time basis. This, in turn, increases flexibility and responsiveness. Logistics functions and firms are using this IT to reroute shipments while in-transit in order to meet customer needs faster. The ability of the Internet to provide quick, accurate data transmission is increasing the overall efficiency of the entire pipeline because managers are receiving better information for decision making and it allows everyone concerned simultaneous access to the distribution channel.[27] Integration of RFID and satellite technology with the capabilities of the Internet makes it possible to relay extensive shipment information such as location, contents and shipping data (for example, origin, destination and priority).

Information System Descriptions

There are numerous DoD logistics and transportation systems in place to provide information on a requisition. Three of these systems were used in this research—the Global Air Transportation and Execution System (GATES), the Logistics Online Tracking System (LOTS) and the Global

Transportation Network (GTN). GATES provides "oversight of worldwide cargo movement" for the airlift portion of the DTS.[28] LOTS is an online automated information system designed for processing and storing logistics data to provide TAV about DoD and civilian agency requisitions and related data.[29]

GTN[30] is an information database accessible via the Internet. Data in GTN is compiled from literally dozens of different DoD and commercial systems. The USTRANSCOM developed GTN "to provide ITV over air and surface shipments moving between ports of embarkation and debarkation (POEs and PODs)."[31] GTN provides a

> seamless, real-time capability to access—and employ—both classified and unclassified transportation and deployment information.[32]

The system is intended to be the integrated transportation portion of the Global Command and Control System (GCCS). As an illustration of its size and responsiveness, the ITV capability in GTN was launched in August 1997 and has a data warehouse of over 43 gigabytes with 80 percent of the information received from the various systems posted within five minutes of receipt.[33]

Uniform Material Movement and Issue Priority System (UMMIPS)

The DoD, through the Defense Logistics Agency (DLA), uses a system of requisition priorities to establish movement standards for all DoD cargo (see Figure 2). The UMMIPS time standards are "the maximum amount of time that should elapse during any given pipeline segment for items that are in stock."[34] The system recognizes the priorities used by both transportation and supply. UMMIPS serves as the "... system for allocating resources among competing demands. It shall be used during peacetime and war."[35] In May 1998, the Under Secretary of Defense for Acquisition and Technology authorized a new set of UMMIPS time standards as part of the new *DoD Materiel Management Regulation, DoD 4140.1-R*. The new standards decreased the maximum time allowed for movement of a shipment as well as redefined the different airlift areas.

Segment	UMMIPS Time Standard (in days)
APOE Port Hold Time	2.0
Transit Time Between APOE and APOD	1.5
APOD Port Hold Time	1.0
AMC Possession Time	4.5

Figure 2. UMMIPS Time Standards for Transportation Priority 1 (TP1) Shipments [36]

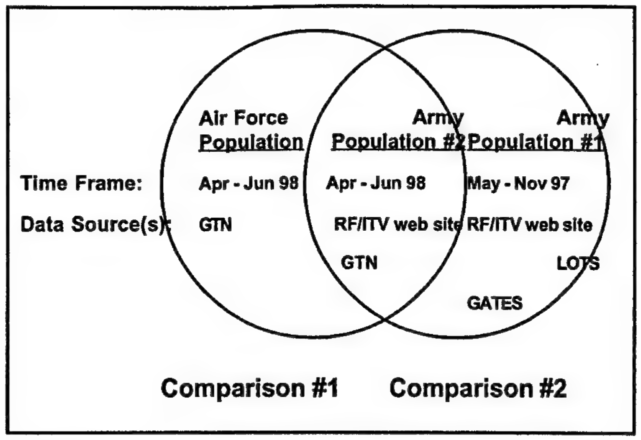

Figure 3. Data Analysis Populations and Information

Methodology

Three sets of data were considered (see Figure 3). All three sets of data considered were shipments originating in the Continental United States (CONUS) with an APOE of Dover AFB, Delaware and an APOD of either Taszar Airfield, Hungary, or Eagle Base, Tuzla, Bosnia. Additionally, all shipments moved through Ramstein AB, Germany, and were in support of OPERATION JOINT ENDEAVOR (OJE) and OPERATION JOINT GUARD (OJG). Thus, routing for all shipments were either Dover-Ramstein-Taszar or Dover-Ramstein-Tuzla.

The primary data consisted of two sets of Army palletized cargo originating from the consolidation/containerization point (CCP) at the Defense Depot, New Cumberland, Pennsylvania. A list of Lead Transportation Control Numbers (TCNs)[37] that were tagged or *burned in* at the New Cumberland depot were retrieved via query from the United States Army Europe (USAREUR) Radio Frequency/In-transit Visibility (RF/ITV) web site.[38] The Lead TCNs collected were matched with relevant transportation pipeline movement data gathered from two sources—the GATES legacy database and the GTN web site.

Transportation movement information for the first population of Army data (Army Population #1) was gathered for high-priority TCNs moving through the AMC portion of the DTS between 9 May 1997 and 29 November 1997. After restricting the initial population to unclassified, non-expedited, non-hazardous, high-priority cargo supporting OJE or OJG, the final population included 189 Lead TCNs.

The second population of Army data (Army Population #2) consisted of high-priority TCNs moving between 1 April 1998 and 26 June 1998. Using the same criteria as for the first population, the second Army sample population resulted in 137 Lead TCNs.

The third (comparative) population was a set of Air Force cargo moving through the same pipeline as both sets of Army cargo. This data set covers the same time period as Army Population #2 (1 April to 26 June 1998). All of the items considered in this population were non-RFID-tagged. The query for Air Force TCNs was conducted using the primary DoD Activity Address Code (DoDAAC)[39] for Taszar (FB5895) and Tuzla (FB5830) and the GTN Cargo Query

screen. The final sample population consisted of 90 Air Force TCNs.

The following data elements were required for each sample population:

1. *Transportation Control Number (TCN).*
2. *Aerial Port of Embarkation (APOE).* This is the point of entry into the AMC portion of the DTS. For this research, the APOE is Dover AFB, Delaware.
3. *Aerial Port of Debarkation (APOD).* This is the point of exit from the AMC portion of the DTS. For this research, the APOD is Taszar Airfield, Hungary, or Eagle Base, Tuzla, Bosnia.
4. *Required Delivery Date (RDD) or Transportation Priority (TP).* This is a code that defines the movement priority of a shipment.
5. *APOE Receipt Time.* This is the time the shipment is received at the APOE via motor carrier.
6. *APOE Lift Time.* This is the time the shipment departs the APOE via aircraft.
7. *In-transit Receipt Time.* For this research, this is the time the shipment arrives at Ramstein AB from Dover AFB.
8. *In-transit Lift Time.* For this research, this is the time the shipment departs Ramstein AB for the APOD.
9. *APOD Receipt Time.* This is the time the shipment is received at the APOD.
10. *APOD Lift Time.* This is the time the shipment departs the APOD, usually via motor carrier.

After eliminating outliers, the Large-Sample Test of Hypothesis for two samples was used to compare the means and standard deviations of the different populations.

Four calculations were used for analysis based on their relationship to the UMMIPS time standards:

1. *Port Hold Time (PHT) at the APOE.*
2. *Transit Time Between the APOE and the APOD.*
3. *PHT at the APOD.*
4. *AMC Possession Time* (sum of segments 1, 2 and 3). This calculation reflects the total time a shipment is in the AMC portion of the DTS.

Comparison 1: Air Force Versus Army Population #2

First, Army cargo had a longer average PHT at the APOE than Air Force cargo for both Taszar- and Tuzla-bound shipments. For Taszar-bound shipments, Army cargo was held at the APOE (Dover) more than 2.5 times longer than Air Force cargo (2.77 days versus 1.02 days). For Tuzla-bound shipments, Army cargo was held at the APOE almost twice as long as Air Force cargo (2.32 days versus 1.18 days). Additionally, the standard deviations for Army shipments are at least 50 percent larger than for Air Force shipments (1.50 days versus 0.98 days [Taszar]; 1.46 days versus 0.79 days [Tuzla]).

Second, Army cargo had a longer transit time from APOE to APOD than Air Force cargo for Tuzla-bound shipments. Army shipments took 24 percent longer to transit from the APOE (Dover) to the APOD (Tuzla) than Air Force shipments to the same destination (2.55 days versus 2.06 days). A factor of interest is that the standard deviation for the Army shipments is twice the standard deviation for Air Force shipments (1.37 days versus 0.67 days).

Lastly, Army cargo had a longer AMC Possession Time than Air Force cargo for both Taszar- and Tuzla-bound shipments. For both destinations, the possession time for Army cargo was 28 percent longer than Air Force cargo (5.11 days versus 3.98 days; 6.27 days versus 4.90 days). Furthermore, the standard deviation for Army shipments bound for Taszar is 35 percent larger than for Air Force shipments (1.91 days versus 1.41 days), and the difference for Tuzla-bound shipments is 88 percent larger (2.44 days versus 1.30 days).

Comparison 2: Army Population #2 versus Army Population #1

The results of the test between the two Army populations indicate there is only one statistically significant difference between the two populations in terms of the Port Hold Time at the APOD for Taszar-bound shipments.

An examination of the means and standard deviations of the compared populations reveals that Army Population #1 cargo had an average PHT at the APOD more than five times that of Army Population #2 cargo for Taszar-bound shipments (0.80 days versus 0.14 days). Although test results indicate this is a significant difference, both means are less than one day and unlikely to be significant to the end-user. However, the difference in the range of PHT data for the Army #1 Population runs from 0.0 days to 8.21 days—with only four observations greater than 2.88 days—whereas the range of Army #2 Population data is 0.0 days to 0.92 days. This may indicate the existence of outliers not eliminated[40] or a reflection of events at the APOD.

Comparison 3: Application of UMMIPS Time Standards

Because the primary comparison of interest is the difference between RFID-tagged and non-RFID-tagged shipments, this discussion will focus on the Air Force and Army #2 Populations. Several observations may be made about the results:

1. *PHT at APOE.* Air Force shipments met the UMMIPS time standards almost twice as often as Army shipments for both Taszar- and Tuzla-bound cargo (92.9 percent versus 43.2 percent and 85.3 percent versus 48.4 percent, respectively).
2. *PHT at APOD.* Army shipments met the standards more often than Air Force shipments for both destinations (100.0 percent versus 92.9 percent [Taszar]; 47.3 percent versus 14.7 percent [Tuzla]). This is the only pipeline segment where RFID-tagged shipments moved faster than non-RFID-tagged shipments for both destinations of cargo.
3. *AMC Possession Time.* Air Force shipments met the standards almost twice as often as Army shipments for Taszar-bound cargo (71.4 percent versus 38.6 percent) and more than 1.5 times for Tuzla-bound cargo (29.4 percent versus 18.7 percent).
4. Throughout the pipeline, *Taszar-bound Army shipments* met the UMMIPS time standards approximately 40 percent of the time, but at the APOD (Taszar), 100 percent of the shipments met the standard.
5. *Air Force Taszar-bound shipments* met the UMMIPS time standards for PHT at the APOE and APOD 92.9 percent of the time, yet only 14.3 percent of shipments met the standard for transit time between the APOE and APOD. Additionally, only 71.4 percent of shipments met the standards for AMC Possession Time.
6. *Tuzla-bound Army shipments* met the UMMIPS time

standard for AMC Possession Time less than 20 percent of the time and never exceeded 48.4 percent in the other three segments.

7. *Tuzla-bound Air Force shipments* managed to meet the standard for PHT at APOE 85.3 percent of the time, yet fell below 40 percent for all other pipeline segments. Also, only 14.7 percent met the standard for PHT at APOD (Tuzla).

Findings

Since the primary comparison of interest is between RFID-tagged and non-RFID-tagged shipments, this discussion will focus on the comparison between the Air Force and Army #2 Populations. This research attempted to answer four questions.

Research Question One

Do shipments tagged with RFID technology and reported directly to a WWW accessible database have an average transit time between the Aerial Port of Embarkation (APOE) and the Aerial Port of Debarkation (APOD) below the average transit time of items not tagged?

For Taszar-bound shipments, there was no reason (no statistically significant difference) to conclude that non-RFID-tagged (Air Force) shipments had a different average transit time between APOE and APOD than RFID-tagged (Army Population #2) shipments.

For Tuzla-bound shipments, there was a significant difference between the means of the two populations at the 0.01 alpha-level of significance. RFID-tagged (Army Population #2) shipments had a *longer* average transit time between the APOE and APOD than non-RFID-tagged (Air Force) shipments (2.55 days versus 2.06 days). However, the results of the two-sample t-test show the test statistic, -2.68, is barely outside the range created by the critical value, ±2.62.

Research Question Two

On average, do RFID-tagged shipments have a smaller average Port Hold Time (PHT) than non-tagged shipments?

For the APOE, RFID-tagged (Army) shipments had a significantly *longer* average PHT (2.77 days for Taszar cargo and 2.32 days for Tuzla cargo) at the Dover APOE than non-RFID-tagged (Air Force) shipments (1.02 days for Taszar cargo and 1.18 days for Tuzla cargo).

A potential reason for this difference may lie in the characteristics of the shipments used in this analysis. Air Force shipments, in general, arrive at the Dover APOE unpalletized whereas Army shipments are consolidated (palletized) at a consolidation/containerization point (CCP) before arriving at the Dover AFB aerial port. One of the last steps made by an aircraft loadplanner in planning a load is the addition of any available (processed) small pieces of cargo for the scheduled destination. In this case, small pieces of cargo (for example, 1-cube, 5-pound boxes) are added to a mission more readily than an entire pallet (of any type of cargo).

A second possibility for the longer average PHT of Army cargo is the arrival rate and quantity of the pallets at the APOE. If pallets arrive with insufficient time to be processed and loaded, they *would not* be selected for an outbound aircraft load and may end up waiting until the next day for movement. Likewise, if large quantities of palletized, RFID-tagged cargo arrive at the APOE at the same time, it could take several airlift missions over several days to clear the backlog of cargo. However, since movement priority is first-in, first-out by transportation priority, this reasoning may not add to the explanation of why the Air Force cargo studied had significantly less PHT unless available airlift is scarce. A third possible explanation is the ability of shipping services to *space-block* or reserve space on channel missions. Any one or all of the above possibilities may explain the differences seen in PHT between the RFID-tagged (Army) and non-RFID-tagged (Air Force) cargo as observed in this study.

For both APODs, there was no reason (no statistically significant difference) to conclude that non-RFID-tagged (Air Force) shipments had a different average PHT than RFID-tagged (Army Population #2) shipments. The average PHT for Army shipments arriving at Taszar was 0.15 days whereas Air Force shipments were held an average of 0.29 days. At Tuzla, Army shipments averaged 1.40 days PHT and Air Force shipments averaged 1.67 days. It is interesting, however, that the PHT for Tuzla is so much larger than the PHT at Taszar.

Research Question Three

On average, do RFID-tagged shipments have a smaller AMC Possession Time (total time between receipt at the APOE and departure from the APOD) than non-tagged shipments?

Test results indicated—for both Taszar- and Tuzla-bound shipments—that RFID-tagged (Army) shipments had a *longer* average AMC Possession Time than non-RFID-tagged (Air Force) shipments. Army shipments destined for Taszar had an average AMC Possession Time of 5.11 days and Air Force shipments averaged 3.98 days. Tuzla-bound shipments averaged 6.27 days for Army shipments and 4.90 days for Air Force shipments. Thus, it took more than one day longer for the RFID-tagged (Army) shipments to move through the system than non-RFID-tagged (Air Force) shipments for both cargo destinations. Because there was no significant difference between the two populations for either the transit time between the APOE and APOD or the PHT at the APOD, the most likely (and obvious) reason for the difference in AMC Possession Time is the PHT at the APOE as discussed in Research Question Two.

Research Question Four

On average, are RFID-tagged shipments more likely to meet Uniform Material Movement and Issue Priority System (UMMIPS) time standards than non-tagged shipments?

In terms of AMC Possession Time, non-RFID-tagged (Air Force) shipments met the UMMIPS time standard (of 4.5 days) more often than RFID-tagged (Army) cargo. As noted previously, non-RFID-tagged (Air Force) Taszar-bound shipments met the standard 71.4 percent of the time and Tuzla-bound shipments met the standard 29.4 percent of the time. Although all shipment types performed poorly, RFID-tagged (Army) shipments only met the standard 38.6 percent of the time for Taszar-bound shipments and 18.7 percent of the time for Tuzla-bound shipments.

The pipeline segment contributing the most to this difference is PHT at the APOE. Despite being palletized and

ready for onward movement upon arrival at the aerial port, RFID-tagged (Army) shipments only met the UMMIPS time standard (of two days) 43.2 percent of the time for Taszar-bound and 48.4 percent of the time for Tuzla-bound cargo. In contrast, non-RFID-tagged (Air Force) shipments met the standard 92.9 percent of the time for Taszar-bound and 85.3 percent of the time for Tuzla-bound cargo. A possible explanation was discussed previously in Research Question Two.

An examination of PHT at the APOD may provide a partial explanation for the significantly lower percent of Tuzla-bound shipments meeting total AMC Possession Time UMMIPS standards. At Taszar, significant percentages of both tagged and non-tagged shipments met the UMMIPS standard for PHT at the APOD (100.0 percent and 92.9 percent respectively) whereas at Tuzla only 47.3 percent of RFID-tagged and a mere 14.7 percent of non-RFID-tagged cargo met the standard. Although the reason for this difference in PHT between these two locations is unknown, it provides some explanation for the lengthy AMC possession time and the inability to meet the UMMIPS time standard.

There is a perception within the DoD that ITV—in the form of Radio Frequency Identification (RFID) technology—will improve transit time through the Air Mobility Command (AMC) portion of the Defense Transportation System (DTS). The results of this research reject this notion.

Conclusion

There is a perception within the DoD that ITV—in the form of Radio Frequency Identification (RFID) technology—will improve transit time through the Air Mobility Command (AMC) portion of the Defense Transportation System (DTS). The results of this research reject this notion. The research results point strongly to the conclusion that RFID-tagged shipments move *slower* than non-RFID-tagged shipments.

First, there are differences in terms of PHT at the APOE. RFID-tagged shipments waited 2 to 2.5 times longer than non-RFID-tagged shipments at the APOE and the variability of the PHT for RFID-tagged shipments was 1.5 to 2 times greater than for non-RFID-tagged shipments. Second, shipments of RFID-tagged cargo destined for Tuzla had a 24 percent longer average transit time between the APOE and APOD than non-RFID-tagged cargo and had 2 times greater variability. Since tagged and non-tagged cargo travel on the same aircraft together and transit time between locations is stable over time, it would be reasonable to attribute this variability to the Port Hold Time at Ramstein AB. Finally, in terms of total average AMC Possession Time, RFID-tagged shipments were in the AMC system 28 percent longer than non-RFID-tagged shipments and also possessed a larger variability.

Ultimately, the RFID technology described throughout this research is intended to aid the end-user; it was not intended to benefit the different transportation nodes. The original purpose behind the implementation of this technology was to enable the requisitioning unit to know where their supplies are and when to expect them; it was not intended to decrease cycle time.

Notes

1. Department of Defense (DoD), *Defense Intransit Visibility Integration Plan.* Washington, DC: GPO, Feb 95.
2. The Defense Transportation System (DTS) is the part of the national transportation infrastructure supporting DoD transportation needs in peace and war. It consists of "those common-user military and commercial assets, services, and systems organic to, contracted by, or controlled by the DoD." *See:* Department of Defense (DoD), *Military Standard Transportation and Movement Procedures (MILSTAMP), DoD 4500.32-R, Vol. I.* Washington, DC: DoD, 15 Mar 87.
3. AMC functions as the DoD's primary source of cargo airlift. The AMC system is set up on a hub-and-spoke concept. Airlift of cargo and passengers occurs via a series of regularly scheduled (frequency channel) missions or on an *as needed* (requirements channel) basis. AMC's airlift hub system consists of several aerial ports (an airfield selected for the air movement and transshipment of personnel and materiel) linked by these channel missions to collect cargo from spoke locations and forward it to the end-user. AMC's five major aerial ports in the Continental United States (CONUS) are at Charleston AFB, South Carolina; Dover AFB, Delaware; McChord AFB, Washington; McGuire AFB, New Jersey; and Travis AFB, California.
4. *Defense Intransit Visibility Integration Plan,* B-1.
5. *Ibid.*, iii.
6. Government Accounting Office (GAO), *Operation Desert Storm, Lack of Accountability Over Materiel During Redeployment,* Report NSIAD-92-258, Washington, DC: GPO, Sep 92.
7. Government Accounting Office (GAO), *1997 Consolidated Financial Statements of the United States*, Report AIMD-98-127, Washington, DC: GPO, 31 Mar 98, [Online], Available: http://www.gao.gov/reports.htm, (15 Apr 98).
8. *Ibid.*
9. *Ibid.*
10. Operation Joint Endeavor (OJE) consisted of North Atlantic Treaty Organization (NATO) multinational forces operating in the Bosnia-Herzegovina theater of operations to implement the military aspects of the Bosnia Peace Agreement signed in Dayton, Ohio, on 14 Dec 95 and occurred between 20 Dec 95 and 20 Dec 96. OJG consists of operations as a stabilization force supporting the Dayton Peace Accords from 21 Dec 96 to the present. *See:* North Atlantic Treaty Organization (NATO). "The NATO-led Stabilisation Force (SFOR) in Bosnia and Herzegovina," n. pag. (Apr 97), [Online], Available: http://www.nato.int/docu/facts/sfor.htm, (23 Jul 98).
11. Department of Defense (DoD), *Annual Report to the President and the Congress,* Washington, DC: DoD, Mar 1996. Excerpt from report, n. pag, [Online], Available: http://www.dtic.mil/execsec/adr96/index.html, (21 Apr 98).
12. *Defense In-transit Visibility Integration Plan*, B-3.
13. Joint Chiefs of Staff (JCS), *Joint Vision 2010.* Washington, DC: JCS, 1995.
14. *Ibid.*, 24.
15. Department of the Air Force, *Air Mobility Master Plan (1998)*, Scott AFB IL: Headquarters Air Mobility Command, 24 Oct 97, [Online], Available: http://www.scott.af.mil/hqamc/pa/about/ammp.htm, (21 Apr 98).
16. *Ibid.*, iii.
17. *Annual Report to the President and the Congress (1996).*

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Botttleneck Information and Reduction: An Analysis of the Logistics Reparable Pipeline

Captain Patrick K. Pezoulas, USAF
Captain Karl N. Muno, USAF

Introduction

This article presents the analysis of select avionics line replaceable units (LRUs) from the F-16 weapon system and centers on depot-sourced Not Mission Capable Supply (NMCS) parts shipments. Lateral supply support was not considered in the analysis. The goal was to identify the specific location of bottlenecks within the logistics reparable pipeline (LRP) and offer recommendations that may reduce or eliminate them.

Analysis identified 641 shipments that exceeded the allowable Uniform Material Movement and Issue Priority System (UMMIPS) time standard. This is an 83.45 percent failure rate.

A total of 768 NMCS, DD Form 1348-1A Issue Release-Receipt Documents (IRRD), were retrieved from the Enhanced Transportation Automated Data System (ETADS). Analysis identified 641 shipments that exceeded the allowable Uniform Material Movement and Issue Priority System (UMMIPS) time standard. This is an 83.45 percent failure rate.

Focusing on F-16 avionics LRUs was not by chance. The top five problem parts, according to the then PACER LEAN project office, were selected for this study.[1] PACER LEAN, at the time was Headquarters Air Force Materiel Command's (HQ AFMC) test program to verify whether the Depot Repair Enhancement Process and Contract Repair Enhancement Program were working as planned. Problem parts are defined as those parts shipments that continually exceed UMMIPS standards. UMMIPS standards are used throughout the DoD and are set forth in *DoD 4140.1-R*. UMMIPS recognizes the priorities used by both transportation and supply.

Data Methodology and Collection

Key questions that drove this study were:

- Do bottlenecks exist within the LRP? If so, where are they and what is the cause?
- How can bottlenecks be reduced or eliminated?

To determine whether bottlenecks exist within the LRP, HQ AFMC/LGTR provided NMCS shipment data from the ETADS. The data set was compared to the UMMIPS standard to verify if shipments met the standard. Only the shipments that exceeded the standard were analyzed. Additionally, each IRRD was physically obtained and reviewed for accurate receipt date information. Each IRRD was separated and evaluated by the following: overseas or Continental United States (CONUS) location, theater of operation, base, supply requisition account number (SRAN) and national stock number (NSN). The AO (customer request), AS (shipment status), D6S (customer receipt) times from the ETADS data, receipt and process dates from each IRRD and Federal Express (FedEx) delivery receipts were used for comparison with the UMMIPS standard.

The LRP time begins when a reparable LRU is requisitioned and ends when the customer receives the part.

In order to accurately identify bottlenecks within any system or process, an accurate measurement of total time spent in that system must be compared to the system standard. The LRP time begins when a reparable LRU is requisitioned and ends when the customer receives the part. A major assumption used in this study was that customer receipt occurred the same day as supply receipt. This assumption is based on the premise that NMCS parts are inherently high visibility assets and an audit trail is required. To evaluate the pipeline performance, the shipment times were compared to the UMMIPS standard. An NMCS part is allowed from seven to 17 days in-transit time, from requisition to customer receipt depending upon the theater of operation. The LRP is divided into the following segments: Requisition (AO), Item Availability (AE), Shipment Status (AS) and Receipt (D6S).

Data division into separate tiers is essential to identify bottlenecks because these divisions help to identify whether bottlenecks occur Air Force-wide, theater-wide or simply at one or more locations.

The first tier evaluation of the 768 shipments found 86 from overseas locations and the remaining 682 were consigned to active or reserve Air Force units throughout the CONUS.

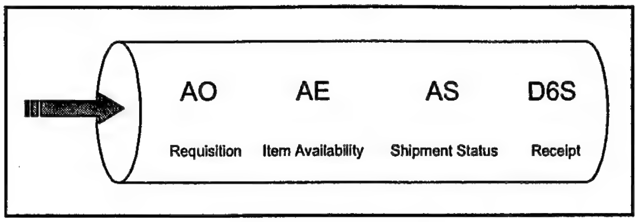

Figure 1. Logistics Pipeline

The shipment information was then divided into overseas or CONUS location by SRAN and DoDAAC (Department of Defense Activity Address Code). The transit time for the 768 shipments was compared with the UMMIPS standard and 641 shipments, 83.5 percent, failed to meet the required standard. Of the 682 CONUS shipments, only 83 met the UMMIPS standard. The remaining 599 shipments exceeded the standard—an 88 percent failure rate.

The second tier evaluation involved the 86 overseas shipments. Only 19 of these 86 shipments met the UMMIPS standard, which equates to 78 percent exceeding the standard. Only two overseas bases, Kunsan AB, Republic of Korea, and Elmendorf AFB, Alaska, met the standard consistently. The reason for this may be due to the intra-theater intermediate depot level repair facility located in Japan which allows Kunsan AB and Elmendorf AFB to have reparable parts repaired and returned more expediently and thus have a faster turnaround time than would be experienced from repair service at a major depot in the CONUS. However, the most significant change is the reduction in transit time. On average, it takes one to three days transit time within the Pacific Air Forces region. This time would dramatically increase if parts had to be shipped to a CONUS facility because of the additional transportation requirements.

The final information needed for this study was the actual customer receipt dates found in the D6S report from base supply. This included identifying the consignee (receiving base) and requesting another IRRD to verify the date of receipt at base supply. For the data collection, only 42 actual documents were received from the base supply document control sections. These documents were examined to verify the actual receipt date by the base supply representative. In most cases the receipt signature was from a commercial carrier representative.

The final step was to evaluate the data by pipeline segment. This was done by extracting the dates from the various data sources and placing them in order of occurrence in the pipeline. The dates were compared by segment with the UMMIPS standard. If the shipment time is one or more days greater than the standard within any one segment, this constitutes a bottleneck.

Results and Analysis

Do bottlenecks exist within the LRP? If so, where are they and what are the causes? Internal bottlenecks and external paperwork delays exist with respect to the LRP.

Do Bottlenecks Exist Within the LRP? If So, Where Are They and What Are the Causes?

Internal bottlenecks and external paperwork delays exist with respect to the LRP. External paperwork delays occur at the base supply receiving section as a result of batch processing. These paperwork delays cause a misrepresentation of the data. It is *highly likely* that a NMCS part is already aboard an aircraft and bound for the consignee. However, batch processing data several days later into the Standard Base Supply System (SBSS) will indicate a longer base supply handling and processing time when in actuality the part is moving through the system in a timely manner.

This study found that FedEx delivered 19 of the 100 randomly selected shipments to the consignees. These 19 shipments reflect the number of shipments that have FedEx data assigned to them in the ETADS, the data source for FedEx shipments. The shipments were in-checked by the receiving section the following business day after being tendered to FedEx. The ETADS data and IRRDs were used to evaluate FedEx's performance. This was done by identifying the date each shipment was tendered to FedEx and by identifying the date each shipment was received at the destination supply's receiving section. The signature date on the IRRD identified whether the documents were batch processed at the receiving section, resulting in an inaccurate reflection of the actual receipt date. If the shipment receipt date annotated on the IRRD is earlier than the Julian date entered into the SBSS, this indicates the documents were received by base supply and then processed some time after the actual receipt date. Only five of

Most Significant Article Award

The Editorial Advisory Board selected "Fightn' N' Stuff," written by Wing Commander David J. Foster, RAF, as the most significant article in the Volume XXII, Number 3 issue of the *Air Force Journal of Logistics*.

the 100 randomly selected shipments were requisitioned using the SBSS method, while the remaining 95 shipments were requisitioned via telephone. The telephonic requisitioning method may offer the customer an expedited requisition when compared to the standard method, but the downside to this method is the loss of control by base supply in the requisitioning process.

Only 63 of the 100 IRRDs were received. This response rate was due to factors such as inadequate quality assurance, lost data or illegible documents. Several bases contacted could not provide any documentation due to faulty computer disc storage.

The overall UMMIPS performance for overseas and CONUS shipments is shown in Figure 2. The data evidence that

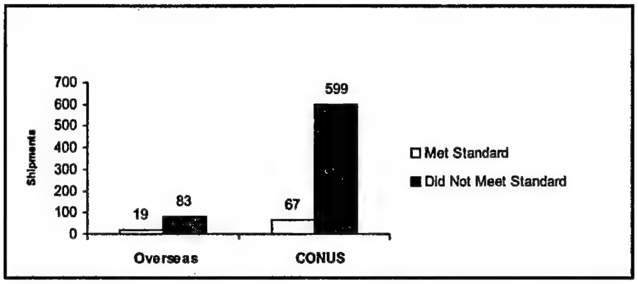

Figure 2. Overall CONUS and Overseas UMMIPS Performance

bottlenecks exist within the LRP.

Figure 3 presents the overall UMMIPS performance for overseas shipments by theater. Over 65 percent of the total shipments in each theater exceeded the standard.

Figure 4 presents the random overseas shipments with the respective UMMIPS performance by theater. The data clearly

The data clearly indicates bottlenecks in the LRP in at least three of the four theaters.

indicate bottlenecks in the LRP in at least three of the four theaters. The Alaskan Air Command did not have any randomly selected shipments evaluated.

Figure 5 presents the randomly selected CONUS shipments and respective UMMIPS performance. Approximately 44 percent of the shipments met the standard, thus confirming some forms of bottlenecks within the CONUS theater.

The data set in Figure 6 indicates that bottlenecks exist within the pipeline at various segments. However, the most prominent location is the AS segment with 49 shipments exceeding the standard. Data analysis consists of 63 shipments with accompanying IRRD. The total number of bottlenecks is 90 with 49 shipments in the AS segment, 23 shipments in the AE segment and 18 combined shipments (more than one bottleneck per shipment).

According to the UMMIPS standard, a CONUS shipment is allowed 1.5 days to pass through the requisitioning process

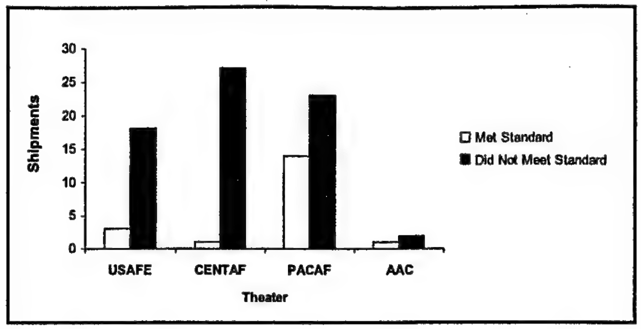

Figure 3. Overall Overseas UMMIPS Performance

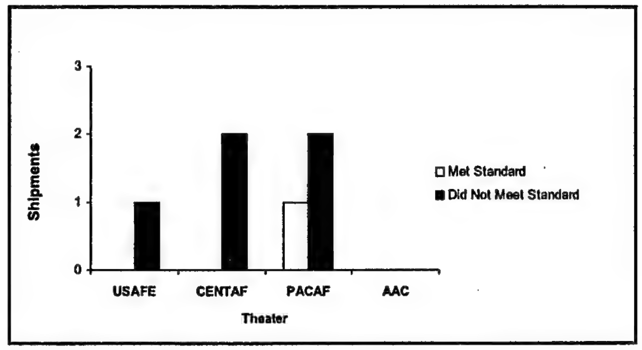

Figure 4. Random Overseas UMMIPS Performance

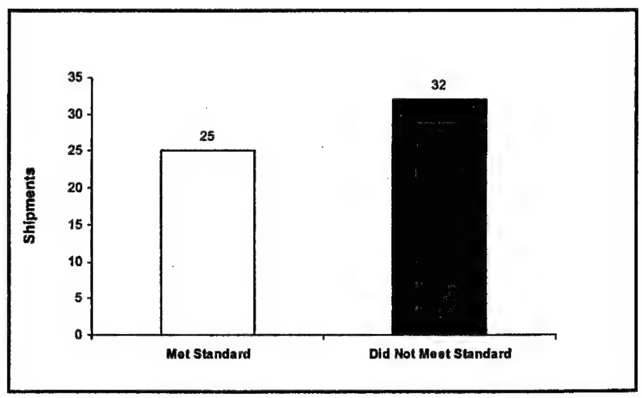

Figure 5. Random CONUS UMMIPS Performance

(AO). The time period begins when the customer requisitions a part. A majority of requisitions are performed via telephonic means, creating a problem determining exactly when the actual requisition occurred.

The original data set included over 768 shipments and only 94 shipments had AO codes assigned. The 63 randomly selected shipment forms were evaluated using the ETADS data and compared with the actual IRRD to identify the requisition date. The data show no shipments exceeding the UMMIPS standard for the AO portion. Within the data collection limits, this supports the conclusion that no bottlenecks exist within this segment of the LRP.

The data in Figure 7 indicate a backorder caused the bottleneck for approximately 60 percent of the shipments.

The evaluation identified 22 shipments exceeding the standard. A more in-depth inspection showed a majority of the delays were caused by an inadequate parts supply. Thirteen of the 22 shipments were backordered (BB) and nine shipment

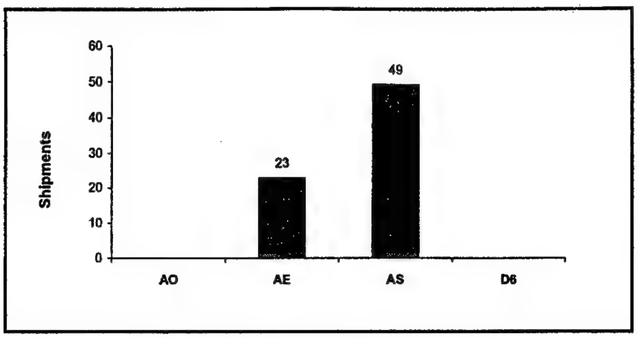

Figure 6. Pipeline Segment Bottlenecks

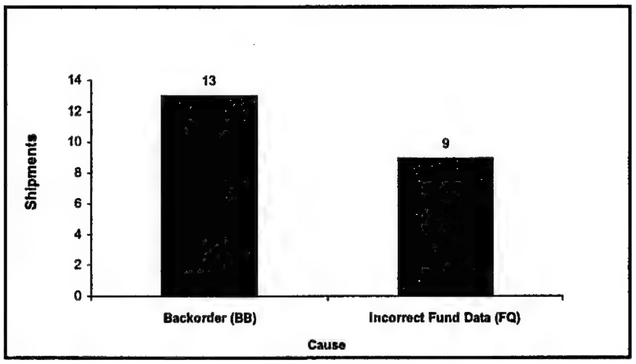

Figure 7. AE Bottleneck Causes

delays were due to a new funding code requirement (FQ).

With regard to the shipment status, AS, of the 63 shipments mentioned above, the data explicitly identify 49 shipments exceeding the UMMIPS standard of one day for CONUS movement and five days for overseas movement. Also, by evaluating each IRRD, Airway Bill or Government Bill of Lading, 27 shipments were shipped over a weekend and 19 shipments were sent second-day air because the government contract carrier does not offer Saturday delivery for cargo weighing more than 150 pounds. The remaining eight of the 27 weekend shipments could have been delivered on Saturday; however, the transportation office must pay a higher price for this service. The remaining 22 shipments were shipped on Monday, Tuesday or Wednesday, with an average in-transit time of 25 days.

. . . a backorder caused the bottleneck for approximately 60 percent of the shipments.

The actual shipping documents and data retrieved from the Visual Logistics Information Processing System (VLIPS) show that some parts were actually shipped under a different transportation priority than what the shipping document indicated. Another cause for the excessive in-transit time was due to the shipment traveling under Mode B, less than truckload (LTL), which takes from seven to 10 days for delivery. Sending an NMCS item by any mode other than next day air will result in a shipment exceeding the UMMIPS standard for the CONUS portion of the shipment.

The D6S receipt segment of the bottleneck was evaluated in the same manner as the AO, AE and AS segments. The shipping documents revealed eight of the 63 shipments were received prior to the date listed in ETADS. Six of the 63 IRRDs received had signed base supply receipt dates by the consignee that were several days earlier than the receipt dates reported by ETADS. The discrepancy in dates leads to the conclusion that upon receipt by base supply, the receiving unit picked up the item or supply delivered the item to the unit. Then, after the customer signed for the item, the IRRD was batch processed several days later into the SBSS. Document batch processing is more likely to occur when Saturday or Sunday is within one day of the date of actual item receipt. Six of the 63 shipments were received an average of five days prior to being processed into the SBSS. This information was taken directly from each IRRD. The actual receipts are more accurate. Shipment receipt dates entered into the SBSS using a batch process causes inaccurate reporting of receipt dates and leads to a misrepresentation of the true performance of the LRP.

Reducing or Eliminating Bottlenecks

All domestic (CONUS, Alaska, Hawaii, Puerto Rico) priority overnight/two-day air express shipments between eight ounces and 150 pounds and up to 119 inches in length or 165 inches in length and girth combined, must be moved using services and rates available through the GSA Small Package Contract. The only exceptions are: shipments of 500 miles or less; shipments made under existing contracts or guaranteed traffic agreements; when required by wartime or contingency operations; and shipments outside the scope of the contract.

In light of the items considered in this research, an obvious solution to the bottlenecks observed is to pay for and generally always use next-day air delivery or Saturday delivery versus two-day delivery. Two reasons argue for this: first, two-day delivery will not meet UMMIPS and second, the difference in cost is insignificant. For example, FedEx charges $224 for next-day deliver and $172 for two-day deliver for shipments with a gross weight of 150 pounds or more.[2] However, since the unit bears the cost of these shipments, a practical decision for the unit may in fact exist during periods of flat or declining budgets. There may in fact be tradeoffs between the bottlenecks in the system, length of time to return an aircraft to mission capable status and the costs associated with next-day delivery.

Increasing the level of on-hand supply to prevent backorders could relieve bottlenecks within the availability (AE) segment of the pipeline. The level of additional spares required was not examined in this study, nor were particular stockage polices or procedures investigated.

Document batch processing is probably the easiest problem to correct. Batch processing is a *free-fix* because the problem can be resolved without the need for additional funding. One solution is to implement a policy that requires the receipt of all shipments to be immediately entered into the SBSS. This action

(Continued on top of page 42)

Simulation: It's the Real Thing

Major Alan W. Johnson, USAF

Introduction

Almost everyone has heard the term *simulation*, but who knows what it really means? Is simulation represented by a wargaming effort, such as Pacific Air Forces (PACAF) units participating in a TEAM SPIRIT exercise? Or, is a better example provided by a C-5 aircrew practicing emergency procedures in a cockpit mockup? Perhaps simulation is best demonstrated by somebody analyzing a computer-based model to determine the expected number of backorders of some reparable item for the Joint Strike Fighter?

Whatever simulation means, the military seems to think it is worthwhile. A few examples: *Joint Vision 2010* specifically cites simulation as a method of improving training realism, promoting readiness and assessing operations concepts.[1] The DoD Directive for defense acquisition *requires* that "modeling and simulations shall be used to reduce the time, resources, and risks of the acquisition resources."[2] Finally, the DoD has established a modeling and simulation master plan[3] and an *entire organization* to address simulation issues.[4]

In fact, simulation includes wargaming, training and analysis. It is generally defined as a modeling *process* whereby *entities* (that is, objects of interest—which can include real people, machines or even failure or repair actions) interact in a defined way, over a period of time. The terms *modeling* and *simulation* are often used interchangeably; however, this is not really correct. A model is simply an approximate representation of some piece of our world. A model can be either *physical* (as in a miniature wooden replica of an aircraft) or *symbolic* (as in the mathematical equation of distance as a product of velocity and time). Simulation is merely one method of building and using a model. For example, other ways of building and analyzing symbolic models include the operations research optimization techniques of linear and nonlinear programming. Baker and Grabau discuss the modeling-simulation distinction in more detail in a recent issue of *Program Manager*.[5]

Simulation is used when other methods are too dangerous, too expensive or impractical. In a wargaming exercise, it is safer to pretend that someone is the enemy instead of engaging a real one and to use laser gear or paintballs instead of real munitions. Since we don't yet have operational experience with the Joint Strike Fighter (JSF), symbolic model simulations are very useful for estimating JSF support requirements. Incidentally, we generally use simulation for symbolic models only when these models cannot be solved by analytic means. This is because simulations typically give us only *approximate* solutions instead of exact values. Furthermore, it is difficult to use simulation to *optimize* a model's input values.

The remainder of this article provides an overview of simulation, with emphasis on logistics modeling. Key DoD simulation agencies are introduced. The critical area of verification and validation is discussed, and the article concludes with recommendations for further reading.

A Simulation Taxonomy

Neyland identifies three commonly used simulation categories: *live*, *virtual* and *constructive*.[6] Live simulation is the process of real people using real machines while pretending to perform some activity, instead of actually doing it. The TEAM SPIRIT example falls into this category. Virtual simulations still involve real people, but now they are using mockups instead of real equipment. A classic example is an aircrew using a cockpit mockup, as in the C-5 example. Finally, constructive simulations consist of models of people and machines. Constructive simulations are typically accomplished by running a symbolic model on a computer. An example would be to run the Logistics Composite Model (LCOM)—a powerful tool that is generally used to identify the best mix of logistical resources to support a given weapon system under operational constraints.[7]

Real Time

A key distinguishing characteristic between live, virtual and constructive simulations is the passage of *time*. Live and virtual simulations both use real time—one second on a wall clock is equivalent to one second of simulation time. In a live simulation such as a RED FLAG exercise, commanders and operators are able to affect the course of the simulation by periodically making decisions or taking action and then observing the effect of those actions. In contrast, constructive simulations typically use either expanded or compressed time—one second on a wall clock could be the same as either a nanosecond or a year of simulation time. For example, in just a few wall clock minutes, an analyst can use LCOM to simulate five years of base-level aircraft support activity. The problem is that after a constructive simulation's initial conditions and runtime constraints are specified, little or no human-model interaction is possible until the simulation run is complete. In our LCOM model, for example, we cannot arbitrarily hit the computer *pause* key sometime during a simulation, pretend an enemy just blew up a back-shop and then *resume* the simulation to see what happens. Instead, both the enemy attack and some feasible workaround strategies for the missing back shop would need to be scripted in, *before* the simulation begins.

A Common Technical Framework

Imagine that we have access to two virtual simulators—a desktop computer-based MiG 23 program and a $10M F-15C motion-base dome simulator. Could we connect the two

systems and let 'em battle it out? Several issues arise: do the two simulations use the same standards for describing and sharing data? Can we synchronize the clock timing of the two simulations? Do the two simulations share a common perception of the battlespace and of each other's respective weapon system capabilities? The idea of linking a desktop computer simulator to a motion-base dome system may seem extreme, but in reality wargamers and others are increasingly interested in the ability to network live, virtual and even constructive simulations into a single effort (that is, into a *system of systems*). If the individual simulations could be truly interoperable, then the limitations of any single component simulation should be transparent to the others. For example, neither our MiG 23 pilot nor our F-15C pilot should be able to tell whether the other is flying a dome or a desktop simulator. The main difference for the two pilots should only be in the amount of realism each experiences in the simulated battle.[8] The need to resolve interoperability issues and promote the reusability of simulations led the DoD to establish a *common technical framework* (CTF), to which individual simulation efforts must conform. The CTF is a product of the Defense Modeling and Simulation Office (DMSO), located in Alexandria, Virginia.[9] The CTF consists of three parts:

- A *high level architecture* (HLA), which is a set of conceptual rules and specifications that prescribe how the different simulations will work together.
- A *conceptual model* of the mission space (CMMS) which is essentially a common understanding of what the real world looks like.
- A set of *data standards*, which includes things like physical data representation, data quality and data security.[10]

Hollenbach and Alexander use the analogy of city planning to illustrate the CTF concept, noting that

> . . . to build and operate an efficient city, a governing framework (for example, street plans, building codes, ordinances) is laid out and certain basic services (for example, utilities, schools, fire protection) are provided. Beyond that the residents are generally left to their own discretion as to what type of home or business they build, who they interact with . . . .[11]

Systems of Systems

Military analysis can benefit from considering virtual *systems of systems*. In November 1997, the Army investigated the denial of global positioning system data on battallion-sized operations by linking four M1A1 Abrams tank simulators at the Simulation Network (SIMNET) facility at Fort Hood, Texas, with two helicopter simulators at Fort Rucker, Alabama, and a fuel truck simulator at Fort Knox, Kentucky. This virtual simulation enabled the Army to predict how soldiers could use new technologies under a variety of conditions.[12]

Wargaming activities frequently use a suite of virtual simulation models. A commonly used simulation is a two-sided theater air campaign model called Air Warfare Simulation Mode (AWSIM). It is typically used to train battle staffs and also acts as a nonscripted command post exercise driver. Another example is the corps battle simulation (CBS). CBS simulates both air and ground forces and is used for battle staff training. Neither AWSIM nor CBS can model all aspects of a campaign and so both are frequently used in conjunction with other simulations during an exercise (for example, AWSIM does not model space-based systems or information warfare).[13]

A principal shortcoming of wargaming simulations is that they do a poor job of modeling logistics.

Logistics Realism

A principal shortcoming of wargaming simulations is that they do a poor job of modeling logistics. For example, a documented problem with AWSIM is its inadequate representation of air/ground mobility and resupply, maintenance, personnel and non-weapon consumption rates.[14] In recognition of this shortcoming and to help train staff logisticians, the Headquarters United States Air Forces in Europe Deputy Chief of Staff for Logistics (HQ USAFE/LG) established the Logistics Exercise Enhancement Program (LEEP). LEEP consists of a Logistics Simulation (LOGSIM) model for replicating base-level logistics and a program of documentation and training support for injecting logistics realism into wargaming exercises. LOGSIM has supported the last three USAFE UNION FLASH exercises and HQ PACAF's ULCHI FOCUS LENS 98.[15] Another wargaming simulation initiative—the Joint Simulation System (JSIMS)—hopefully will increase logistics emphasis. The JSIMS goal is to be "the primary modeling and simulation tool to support future joint and Service training, education, and mission rehearsal."[16, 17]

Constructive Logistics Models

Over the years, logistics has probably benefited more from constructive simulation modeling (such as LCOM) than from virtual simulation efforts. One reason is because constructive simulations are particularly useful for analysis. Logistics problems are frequently too difficult to solve by analytic methods. For example, monthly demand for spare parts is typically random. This demand uncertainty makes an inventory problem much harder to solve than an inventory problem with constant demand and when an analyst must determine optimal stocking levels and reorder points for many parts at once, the problem becomes enormous. RAND's Dynamic Multi-Echelon Technique for Recoverable Item Control (Dyna-METRIC, version 6) was one of the early popular simulation models developed for Air Force problems in reparable inventory theory.[18] Previous, analytic versions of METRIC were based on steady-state conditions that precluded modeling dynamic factors like wartime surges in aircraft usage rates and uncertain support capabilities. Dyna-METRIC can handle these dynamic factors while also accommodating lateral resupply—which is very difficult to

capture in an analytic inventory model. The gains in modeling flexibility from simulation do not come for free, however. Because Dyna-METRIC is a simulation, it cannot optimize spares requirements to achieve specific goals.[19] A more recent inventory analysis simulation example is provided by the Defense Logistics Agency's (DLA) Performance and Requirements Impact Simulation (PARIS) model. PARIS is used to examine investment, inventory and supply chain policies for the more than 1.9 million spare parts that DLA manages. It can simulate two years of demand on 190,000 items in under two hours.[20]

Inventory problems are certainly not the only logistics problems that benefit from simulation. LCOM is widely used to address a variety of base-level logistics issues including sortie generation rates, personnel requirements and aircraft availability.[21] For example, the F-22 System Program Office is now using LCOM to estimate sortie generation rates and maintenance personnel requirements.[22]

Transportation theory can also benefit from simulation modeling. Air Mobility Command (AMC) uses the Airlift Flow Model (AFM)—a simulation model embedded within the Mobility Analysis Support System—to assess policies for airlift control, mission planning and mission execution. The AFM provides a global airlift simulation of AMC and commercial airlift assets in strategic and theater operations. AFM can simulate airborne refueling, aircrews and their flying hour limits and all phases of aircraft ground handling. Since its development, no serious airlift analysis has been performed without at least comparing the results with output from AFM.[23]

Constructive Simulation Tools

Throughout the 1980s, the suite of available simulation tools was pretty limited. Personal computers were not very powerful and few commercial simulation software packages existed. The analyst was mostly limited to writing simulations in a general purpose language (such as PASCAL or FORTRAN [Formula and Translation]), and running the models on a mainframe computer. The result was that simulations tended to be difficult to build and maintain and were seldom interoperable. Things have changed dramatically in the last ten years. Today over 40 different commercial simulation software packages are available.[24] The tremendous improvements in personal computer hardware help analysis as well. For example, DLA's PARIS simulation was built using AweSim™ (a commercially available simulation program) and runs on an NT® workstation. PARIS replaces a mainframe computer-based FORTRAN model that was difficult to maintain and change.[25]

Some constructive simulations can even be run on a standard personal computer spreadsheet! *Monte Carlo* simulations are those in which time has no real relevance to the problem. Instead, the goal is to determine the outcome of a series of random experiments. For example, a gambler does not really care how long it takes to play a series of poker hands. The important aspect is whether the gambler wins or loses each game. If we were to simulate the reliability of an aircraft landing gear over a series of landings, we would be more interested in the landing gear's failure history than on how long each landing takes. Spreadsheets can readily accommodate Monte Carlo simulations, especially when a spreadsheet *add-in* such as Decisioneering's Crystal Ball or Palisade's @Risk is used. Dyna-METRIC is a (non-spreadsheet based) Monte Carlo simulation.

Simulation Model Credibility

No discussion of simulation is complete without addressing model *verification* and *validation* (V&V). In fact, this topic is so important that the DoD issued *Defense Instruction 5000.61, DoD Modeling and Simulation Verification, Validation, and Accreditation*, in April 1996. The Air Force also has guidance, found in *AFI 16-1001, Verification, Validation, and Accreditation*, dated June 1996. Verification seeks to address whether we have built our *model right* (does our model satisfy our design requirements?), while validation focuses on whether we have built the *right model* (are our design requirements themselves correct?).[26]

The real goal of V&V is to get the principal users of a simulation model to feel confident about it. The outcome of a V&V effort is *not* a yes/no answer—there is no such thing as absolute validity. We usually do not have enough time or money to check every aspect of a model. Finally, there is no such thing as *general* validity—a model that is valid for one purpose may not be valid for another.

Symbolic models are typically verified by using standard computer programming debugging techniques. Example methods include building and checking a model in logical chunks, starting with a simple model and adding complexity only as needed and ensuring that units of measurement are consistent. Sometimes a simulation model can be simplified, and its output compared with an analytical result.

Validation is generally harder to perform than verification. Validation asks: how does the simulation model compare to reality? We want the model to be *good enough* to use in the same way we would use the real system. This implies that a model's assumptions and limits must be clearly defined and documented, else we risk using the model under conditions that render it invalid.

A key V&V goal is to develop a simulation model with high *face validity*. This means that the model and its output seem *reasonable* to experts in the field. A typical validation method is to compare a model's output to historical data (if available) or to the output from a similar simulation model. For example, DLA compared their PARIS model results to output from the model it replaced, because changes in policy and demand patterns made it impractical to compare PARIS output to historical data.[27] Another way to boost face validity is to involve the model's eventual users continuously throughout the model's development. Regular involvement is a great way to promote user *buy-in* to the overall effort and ensures that nobody is surprised over what the final simulation model can or cannot do.

Finally, note that ease of validation depends on the actual system of interest. It would be straightforward to validate a simulation model of some aspect of a current depot's operation, because the real operation is an existing, observable process. Now imagine how we would validate a model of on-equipment maintenance in the proposed Space

Station. The best we could probably do would be to compare our model's output to data from Skylab or the Russian MIR program.

Simulation Education

At least one course on simulation is offered in many graduate schools, including most civilian universities, the Air Force Institute of Technology (AFIT) and the Naval Postgraduate School. AFIT *requires* that a simulation course be taken by students in logistics masters degree programs. A typical simulation course teaches the *constructive* modeling aspect of simulation—for some reason, little emphasis is placed on *live* or *virtual* simulation. Law & Kelton[28] and Banks, Carson and Nelson[29] represent the two most popular textbooks on constructive simulation modeling.[30]

Virtually every military member is likely to participate in or be affected by a simulation effort during the course of a career.

Conclusion

Virtually every military member is likely to participate in or be affected by a simulation effort during the course of a career. Why? Simulation helps us get the most benefit from our defense dollars. We can use simulation to help warfighters train, to develop doctrine and to perform analysis on almost any military topic. An increasing need exists to be able to integrate *live*, *virtual* and *constructive* simulations into *systems of systems*. The DMSO's common technical framework is the key initiative that will make these systems of systems feasible. Finally, we must never depend on simulation modeling as a complete replacement for working with reality. Real systems contain subtleties and uncertainties that our models will probably never capture completely. However, simulation can give us useful insights at a fraction of the cost and risk.

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Major Johnson is currently an Assistant Professor of Logistics Management, Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Mergers and Acquisitions in the Defense Industrial Base—Should the US Military Be Concerned?

Lieutenant Colonel Kevin A. Bell, USAF

Editor's Note: Mergers, consolidation and acquisitions within the industrial base are particularly relevant issues for today's military. The potential impact regarding cost, weapon system support and spares availability is enormous. The article that follows provides a solid introduction to both the issues and potential issues associated with changing conditions in the defense industrial base. The paper on which this article is based was completed in March 1998 as a requirement of the Air War College Resident Program.

Introduction

> The successful powers will be those who have the greatest industrial base. Those people who have the industrial power and the power of invention and science will be able to defeat all others.[1]

Leo Amery, a noted British imperialist, made this statement over 90 years ago, and in the 20th Century, his declaration was validated by the results of two world wars and a cold war. These conflicts among the world's great industrial powers demonstrated the importance of having the right quality and quantity of advanced weapon systems. These systems were instrumental in the success of the United States and its allies and were provided primarily by the defense industrial base. While there have been many changes over the past century in security affairs, Mr. Amery's declaration remains true today.

In July 1997, Norman Augustine, formerly of Lockheed Martin Corporation, referred to the defense industrial base as "America's fifth armed force."[2] While some might consider this analogy by the president of the world's largest defense contractor a bit of an overstatement, the successes of the 20th Century demonstrated the importance of the defense industrial base in achieving the nation's security objectives and in executing the national military strategy. The former Chairman of the Joint Chiefs of Staff (CJCS), General Shalikashvili, in his 1997 National Military Strategy Document advises that the success of *Joint Vision 2010* rests on two foundations—one of which is technological innovation.[3] General Shalikashvili also stated that success in preparing for an uncertain national security future "demands a stabilized investment program in robust modernization that exploits the RMA (Revolution in Military Affairs)."[4] The technological innovations and modernization the former Chairman speaks of are provided to the armed forces primarily through the nation's defense industrial base.

The *defense industrial base* is defined as business firms who directly or as subcontractors supply products or services to the Department of Defense (DoD).[5] This critical capability, which is vital to implementing our national military strategy, has within the last decade gone through some dramatic changes. These changes can be traced to the significant reduction in defense spending since the mid-1980s. In turn, defense contractors restructured, consolidated or merged to reduce costs and eliminate excess capacity. As a result, the defense industrial base is left with a much smaller number of prime contractors.

This article reviews recent changes within the defense industry and examines the effects such changes might have on the ability to conduct military operations. Specifically, it addresses the significant reduction in large defense firms capable of producing and delivering complex weapon systems and the concentration of market share in some key military product lines. Key issues are presented, to include the expected loss of competition from mergers and consolidation (horizontal integration). Other issues include increased vertical integration among prime contractors and the potential impact of consolidation on technology development. The article concludes with a brief review of key DoD initiatives intended to mitigate these concerns and a review of other options that offer some possible benefits.

Defense Drawdown

Mr. Perry met with industry leaders at what has since been referred to as the *last supper* to inform them there were twice as many prime contractors at the dinner as he wanted to see in five years.[7]

Defense spending has dropped significantly since the peak of the last defense buildup in the mid-1980s. The combination of the American public's desire to cut defense spending combined with the end of the Cold War resulted in the fourth major drawdown since the end of World War II. As a result, overall defense spending was cut by about one-third. The procurement portion of the budget shrunk even further. This portion of the defense budget, which is used to procure weapon systems and most equipment needed to conduct military operations, is down over 65 percent since the peak spending of the Reagan years.[6]

Because of the significant decline in defense spending and

with encouragement from the DoD, the defense industry restructured to reduce costs. This was done by either eliminating excess plant capacity or divesting their defense business. For a number of defense contractors who remained, they began to acquire other defense business entities through mergers and acquisitions. The DoD encouragement for restructuring came on one occasion in 1993 from then Deputy Secretary of Defense William Perry. Mr. Perry met with industry leaders at what has since been referred to as the *last supper* to inform them there were twice as many prime contractors at the dinner as he wanted to see in five years.[7] His objective was aimed at telling these industry leaders he envisioned a future industrial base with a few strong prime contractors operating facilities at near full capacity instead of a larger number of contractors operating inefficiently at significantly reduced capacity. In order to assist industry with the restructuring required after a merger or acquisition, a policy review completed in July 1993 determined that contractors could obtain reimbursement for restructuring costs if it was determined to be in the best interest of the government.[8] According to Dr. John Deutch—then Under Secretary of Defense for Acquisition (USD(A))—when he approved the decision the DoD had sound rationale for the policy update.

> For over 5 [*sic*] years now, powerful economic forces have been at work shaping our Nation's defense industries. Chief among these is the tremendous decline in the overall DoD budget. Like other businesses in the face of a [*sic*] shrinking customer base, US defense manufacturers must respond. They must consolidate facilities, reduce overhead, look for new markets and eliminate excess capacity to remain competitive and financially viable and they are doing just that.[9]

Dr. Deutch went on to say in his testimony before Congress, that the DoD and taxpayers could save "billions of dollars in costs" through these restructurings and estimated the potential savings from one and a half to seven times the restructuring costs.[10] He also stated if these costs were not reimbursable it would "discourage the rational downsizing and restructuring that we need."[11] The expectation was the government would see these savings in future cost-type contracts. As of March 1997, the DoD had permitted contractors to claim over $700M in restructuring costs based on expected savings of nearly $4B.[12]

Combined with the reduced defense spending and encouragement and financial assistance from the DoD, the defense industry quickly responded with more merger and acquisition activity. According to a Defense Science Board Task Force, this contraction in defense spending resulted in more large-scale industry consolidation than at any other time since after World War II.[13]

Merger and Acquisition Activity

The magnitude of the merger and acquisition activity within the US defense industry has been remarkable given the relatively short period of time in which it has occurred. Based on a report by the Defense Science Board released in the spring of 1994, over 300 defense related mergers and acquisitions occurred during the previous 15 years in the US.[14] The five largest defense contractors at the end of 1996 have evolved from the consolidation of no less than 50 business units since the early 1980s.[15] About 30 of those mergers and acquisitions occurred just since the early 1990s.[16]

Two significant consolidations involved The Boeing Company. In December 1996, Boeing announced its plan to merge with the McDonnell Douglas Corporation. This deal, which cost approximately $14B, created a firm with expected annual sales revenue of about $50B and 200,000 employees.[17] In addition, Boeing completed the acquisition of the defense operations of Rockwell Space and Defense in December 1996.[18] This acquisition cost Boeing approximately $3B and combined with the McDonnell Douglas deal established the company as the second largest US defense contractor.[20]

In sum, there has been a significant number of mergers and acquisitions within the defense industrial base during the past 20 years. This consolidation has left the DoD with just a handfull of prime contractors capable of producing complex weapon systems. An obvious question is whether or not this period of massive industry consolidation has or will impact these contractors' capability to provide high quality, affordable weapon systems necessary for military operations in the 21st Century.

The US military should be concerned about . . . the effect a loss of competition might have on the DoD's ability to acquire the most advanced weapon systems at an affordable price.

Issues and Concerns

The US military should be concerned about both the level and magnitude of mergers and acquisitions within the defense industrial base. The overarching reason stems from a potential loss of competition and the effect a loss of competition might have on the DoD's ability to acquire the most advanced weapon systems at an affordable price.

Members of Congress have recognized the potential problems associated with mergers. According to US Senator Bob Smith (Republican, New Hampshire), a member of the Senate Armed Services Subcommittee on Acquisition and Technology:

> I believe these mergers are a survival issue for the companies involved, but my biggest concern is that America's defense industrial base is shrinking considerably, and I'm not sure anyone has really thought through the big picture in terms of what that means to our national security. I don't think it's particularly healthy to have two or three major defense contractors controlling 70-80 percent of the industrial base.[20]

Unfortunately, even with the interest at senior levels of government there does not appear to be much solid data which unequivocally identifies if there *is* or if there *is not*, a competition problem. In fact, the General Accounting Office

(GAO) indicated in a January 1997 report on this topic that "there is little consensus on how to measure competition."[21] However, there is sufficient concern to warrant some action to curtail further consolidation until a detailed analysis can be completed. As a start, the DoD and the GAO should investigate more accurate means for measuring competition to confirm the extent of the problem.

Market Concentration

The defense industry has become significantly more concentrated in certain defense industry sectors. Looking back to the end of World War II, the US had 26 aircraft, 16 tank, 22 missile and 36 ship and submarine manufacturers.[22] As recent as 1994, these numbers had decreased to seven aircraft, two tank, nine missile and five ship and submarine contractors.[23] By 1996, according to the Defense Logistics Agency (DLA), the US possessed only two contractors who produced bomber aircraft, four who produced fighter aircraft, one tank contractor, one strategic missile contractor and two expendable launch vehicle contractors.[24]

DoD Industry Market Share[25]

Fixed-Wing Aircraft

In 1996 total fixed-wing aircraft purchases exceeded $12.5B.[26] Boeing (McDonnell Douglas) accounted for over 68 percent of the market share. Lockheed Martin and Northrup Grumman sales accounted for almost 29 percent of total sales.[27]

Aircraft Engine Sales

Total aircraft engine purchases in 1996 reached almost $4B.[28] Sales for the top three companies exceeded 78 percent of the total.[29] United Technologies led in market share with over 41 percent, General Electric acquired just over 25 percent and a foreign firm, Rolls Royce PLC captured just over 12 percent of the market.[30]

Helicopters

Two companies dominated the helicopter market: Boeing (McDonnell Douglas) and United Technologies. Total sales in 1996 exceeded $1.2B with Boeing capturing about 37 percent and United Technologies held 36 percent of the DoD market.[31] The next competitor, Textron Inc., had just over 9 percent of the market.[32]

Missiles

Missile sales in 1996 exceeded $3.6B when two market competitors acquired over 84 percent of sales: Lockheed Martin and Raytheon (Hughes).[33] Raytheon captured over 42 percent and Lockheed Martin just below 42 percent.[34]

The defense market is in fact concentrated in certain defense-unique product areas. In markets such as tanks, military aircraft and helicopters and missiles only four or less legitimate competitors exist. The potential loss of competition in the defense industrial base does not stop with the horizontal mergers discussed.

Vertical Integration

Vertical integration is the ability of a prime contractor to produce the subsystems and components necessary to deliver a completed defense product or weapon system. When contractors prepare proposals in response to a government Request For Proposal for a major system, they develop a *make or buy* plan. This plan includes the details of the prime contractor's intent to internally produce the subsystems and components or subcontract for the production of these items to suppliers outside of the company. What consolidation has done is increase the level of vertical integration throughout industry and raised concerns over anti-competition practices. The DoD was concerned enough with this issue in 1996 to charter a Defense Science Board Task Force to look into the matter. The task force identified four key vertical integration concerns.[35] These were large contractors who might: (1) prefer newly acquired suppliers over external suppliers even if the external suppliers were superior; (2) increase barriers to market entry for their competitors; (3) compromise proprietary information obtained on competitors through acquisition of their competitor's supplier(s); and (4) refuse to use suppliers owned by their competitors.[36]

The DSB report concluded that consolidation within the defense industrial base has increased vertical integration among some firms.[37] While this was not viewed as a primary goal of market consolidation, it has occurred and presents an opportunity for prime contractors to manipulate competition to their advantage. During Senate confirmation hearings, Mr. Jacques Gansler, the Under Secretary of Defense for Acquisition and Technology, expressed a major concern for ensuring adequate competition at the subcontractor level for the defense industry.[38] Maintaining competition at the subcontractor level is a key approach to deal with the extensive horizontal consolidation in the defense industrial base.

Technology Development

Another area of concern caused by consolidation is the increased concentration of defense prime contractors who perform R&D.[39] This was a significant portion of the over $22B awarded for 1996 and gave these firms a significant advantage over the rest of the defense market in being able to maintain the latest facilities and staffs.

In addition to the loss of competition from market concentration among R&D firms, prime contractors in many cases have shown a reticence to invest their own funds in developing new and innovative technologies. Without the pressure of adequate competition, what incentive do these firms have to pursue the types of technological advances necessary to field the world's best weapon systems? In a limited competition environment, they can settle for their existing portion of the defense procurement budget and postpone R&D, in order to cut costs, without concern for loss of market share. This type of behavior was mentioned in a *Washington Post* article that suggested in the case of market duopoly:

> . . . well-matched competitors almost never get into wars over prices or innovation. The reason is simple: they both usually come out losers if they do.[40]

The rationale suggests that two competing firms are often unwilling to take on the risk of developing new technology because each could match the other's efforts and the result could be no change in market share.[41] This situation is further illustrated in both Europe and Japan. Governments in both regions discovered there was less breakthrough innovations in markets of very limited competition because they discourage innovation.[42]

Initiatives to Deal With the Consolidated Industry

In June 1993, the Under Secretary of Defense for Acquisition provided US policy objectives for the defense industrial base.[43] These objectives included the need to sustain production capability to support military operations, maintaining an advanced R&D capability and a reconstitution capability in case of national emergency or war.[44] This policy was transformed into a strategy that emphasized maximum use of the commercial sector while preserving the unique capabilities of the defense industrial base. To assist in the effort, the DoD further refined its approach. Acquisition Reform initiatives included revising directives and regulations to maximize use of commercial business practices in the acquisition process, eliminating use of unnecessary military specifications and standards and encouraging development of dual-use technologies and flexible production methods. In addition to these initiatives, which are primarily aimed at reducing barriers for industry participation, the DoD has also taken some steps to protect those industrial areas that are unique in their defense orientation.

Antitrust Review Policy and Process

One step taken within the DoD to deal with defense industry consolidation was to charter a Defense Science Board Task Force to look into the antitrust aspects of mergers and acquisitions. The DoD acknowledged their participation in antitrust reviews was lacking and directed the task force to "provide advice on the Department's participation in antitrust review of defense industry mergers and joint ventures."[45] The task force, cosponsored by the Under Secretary of Defense for Acquisition and Technology and the General Counsel, concluded that existing merger guidelines used by the antitrust agencies (Antitrust Division of the Department of Justice and the Federal Trade Commission) were adequate for this period of defense industry consolidation and the antitrust agencies were receptive to the DoD involvement in such reviews.[46] Following the release of their report, the DoD formalized its policy on participation in antitrust reviews in *DoD Directive 5000.62*. According to a subsequent task force formed in May 1996 to look at vertical integration within the defense industry, the DoD involvement in the antitrust process is now working well.[47]

Some techniques used by the antitrust agencies to resolve competition-based antitrust concerns are forcing the divestiture of business entities or the creation of a *firewall* between business entities. The firewall is intended to prevent anti-competitive behavior while permitting a proposed consolidation to occur. One example of such an action occurred during the review of the Lockheed and Martin Marietta merger in 1995. A firewall was established that prevented Martin Marietta from making any changes to its LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) system that would discriminate against other domestic aircraft producers who might compete with Lockheed.[48]

Vertical Integration

A preventive step taken by the DoD to protect the defense industrial base addresses the concerns of vertical integration. The potential exists for prime contractors with a high level of vertical integration to limit or control competition. One example is a prime contractor compromising proprietary design and production information belonging to a competing firm.[49] The proprietary information could be obtained from a newly acquired subcontractor who previously was subcontracted to the firm who owns the information. In turn, this could lead to a contractor relying on the technological innovation of a competitor. Other examples that could lead to limiting competition include preference of internal suppliers over external suppliers, not using suppliers owned by competing firms and increasing market barriers for entry of competitors.[50] All these actions can lead to a prime contractor manipulating the market to an unfair advantage.

The Defense Science Board Task Force concluded that industry consolidation had resulted in increased vertical integration among defense prime contractors. The task force recognized that the DoD was already dealing with vertical integration through its participation in antitrust reviews and through management of existing acquisition programs. The task force felt the antitrust review process was adequate to address both vertical and horizontal competition concerns, however, the management of DoD acquisition programs required some additional protective measures.[51] To deal with the concerns, the task force made five specific recommendations to focus the DoD's awareness of the effects of vertical integration.[52] They suggested that the DoD should:

1. Monitor key product areas that affect multiple programs; program managers should manage potential vertical integration problems within their own programs.
2. Foster competition and innovation through appropriate acquisition and technology strategies.
3. Pay close attention to the potential antitrust problems caused by vertical integration.
4. Update acquisition education programs to improve the ability of the acquisition workforce to deal with vertical integration concerns.
5. Develop some tools or indicators to measure potential problem areas in vertical integration. Suggested indicators included identifying product areas where less than three prime competitors remained, tracking prime contractors decisions to change from a *make* to a *buy* decision in critical technology areas and tracking competitors' capabilities in discriminating technologies developed under DoD funding.

As a result of the report, the Under Secretary of Defense for Acquisition and Technology issued a memorandum implementing these recommendations.[53] He directed the Deputy Under Secretary for Defense (Industrial Affairs and Installations) to lead in implementing the recommendations.

Other Options to Consider

Even with the Revolution in Military Affairs and the emphasis on commercial technologies to meet defense needs, there is still a requirement for some unique weapon systems and military equipment that cannot be provided by the commercial sector. Examples include missiles, munitions, fighter and bomber aircraft, nuclear submarines, tanks and artillery systems. For those products, efforts must be made to preserve unique and specific capabilities within the defense industrial base. In order to preserve these kinds of capabilities other alternatives need to be considered.

Foreign Participation

One option to consider is allowing foreign firms to participate in the competition for unique defense systems. However, it must

be recognized that the European industrial base has been in the process of consolidation in much the same fashion as in the US.[54] Given the limited number of prime contractors that remain for certain product areas, this option offers the possibility of increased competition and associated benefits. More than likely, this option would face many legal, political and technical hurdles before it could become a reality. Legislative reform would be required to permit increased foreign purchases. For instance, the Buy American Act of 1933 requires weapon systems bought by the federal government to be procured from US businesses or approved designated countries.[55] Such a legislative change would surely face opposition by US organized labor. However, there are subcontracting possibilities. Currently, foreign firms are providing some subsystems and parts to the DoD. In 1996, Rolls Royce PLC was the third largest supplier to the DoD for aircraft engines.[56] Rolls Royce PLC received over 12 percent of the total value of engine contracts.

Subsidizing Critical Product Areas

Subsidizing to keep an industrial capability is also an option that should be considered. This approach may be necessary when competition is extremely limited—or when only a single contractor exists. Subsidizing maintains some level of competition by keeping additional firms in the market. Unfortunately, this approach is not considered very cost-effective when market demand does not support additional firms. The trade-off is whether or not it is more cost-effective to subsidize an additional contractor or pay the additional cost, in higher prices, in a less competitive market. The cost to keep an additional contractor viable could be viewed as insurance and could be offset by the savings received from competition within the market. This kind of subsidy is usually provided in the form of limited production quantities to keep a production line operating.

Another consideration when making a decision to subsidize is whether or not a surge capability is needed. In previous years, the DoD has in fact maintained such capabilities. The practical decision that must be made is the degree of surge capability required and the amount of surge capability that can be afforded.

Nationalizing Defense Unique Industry

Nationalizing the defense-unique portion of the industrial base is also another option. While this is contrary to current competitive sourcing and privatizing initiatives, it may become necessary to protect any unique defense areas of the industrial base that otherwise would not survive. This approach has been used in foreign countries where tight government controls were required in the absence of competition in the market to control prices. While this approach may not be necessary at the present, it should not be dismissed from future consideration.

Summary

If the conflicts of the 20th Century have taught us anything, it should be that the US cannot always pick when or where the next major military conflict will occur. Even during the bipolar era of the Cold War, the US did not always know. And while the current threat does not risk our national existence, the US still faces an uncertain world where a major military response may be necessary to protect vital US interests or those of our allies.

To deal with these uncertainties, the US must maintain a responsive industrial capability to provide the weapons and equipment necessary to respond to such threats. This is especially important for those unique defense systems such as military aircraft, tanks, ships and missiles.

The defense industry has reached a point where there is not much room for additional horizontal consolidation. Presently, only a handful of major firms remain to provide these advanced weapon systems and the risk to competition has become significant. The government response to maintaining competition during this consolidation has seen limited success and more must be done. First, further investigation is necessary to adequately measure the effects of consolidation on competition. In addition, we need to look at some near term options that could provide success such as limiting further vertical integration and expanding opportunities for foreign firms. Other options such as subsidizing unique defense product areas or even nationalizing offer some potential for relief but involve significant government oversight and cost. With declining—or at best, level—defense budgets for the foreseeable future, the DoD must find a cost-effective means for dealing with this issue and must do so in such a fashion to keep the US combat forces supplied with the most advanced weapon systems necessary to carry out the mission of *Joint Vision 2010* and beyond.

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(Continued on bottom of page 42)

CANDID VOICES

Agile Combat Support From the OC-ALC Engine Shop Viewpoint

Major Jon Larvick, USAF

Introduction

Force drawdowns, lean logistics processes, base realignment and closures, Agile Combat Support—these are just a few of the recent initiatives focused on posturing the military for the 21st Century. This article takes a look at some of the effects of these and other Air Force logistics initiatives on engine repair processes taking place on the depot's shop floor. This article will take the Agile Combat Support initiative[1]—the focus of combat support shifts from maintaining massive inventories to establishing a response capability—as the goal and will focus on the changes happening/required on the engine shop floor at Oklahoma City Air Logistics Center (OC-ALC) to make that concept a reality.

Background

The Propulsion Directorate, OC-ALC, is tasked with the worldwide management of many of the Air Force's turbine engines. Within this Directorate, the Propulsion Production Division manages the repair and overhaul of over 700 engines and nearly 1.2 million repair hours of engine components annually.

This engine repair/overhaul process falls within what is defined as *a reparable-item inventory system*. A reparable-item inventory system is a system used for controlling items that are generally very expensive and have long acquisition lead times.[2] Hence, it is more economical to design these items so they are repaired after they fail, rather than treating them as consumable items which are disposed of after use. A standard military reparable-item inventory system consists of a repair facility (depot) dedicated to support several locations (bases) dispersed over an extensive geographical region where equipment (aircraft) is assigned. Over time, equipment malfunctions occur due to the failure of a specific item (engines or engine components) internal to the equipment. A corresponding serviceable item is then obtained from an inventory location and installed on the malfunctioning equipment, thereby restoring it to full operational capability. The failed item is tracked as it is shipped to the repair facility, scheduled for repair and subsequently shipped in a serviceable condition back to an inventory location.[3]

The Propulsion Production Division has two branches that

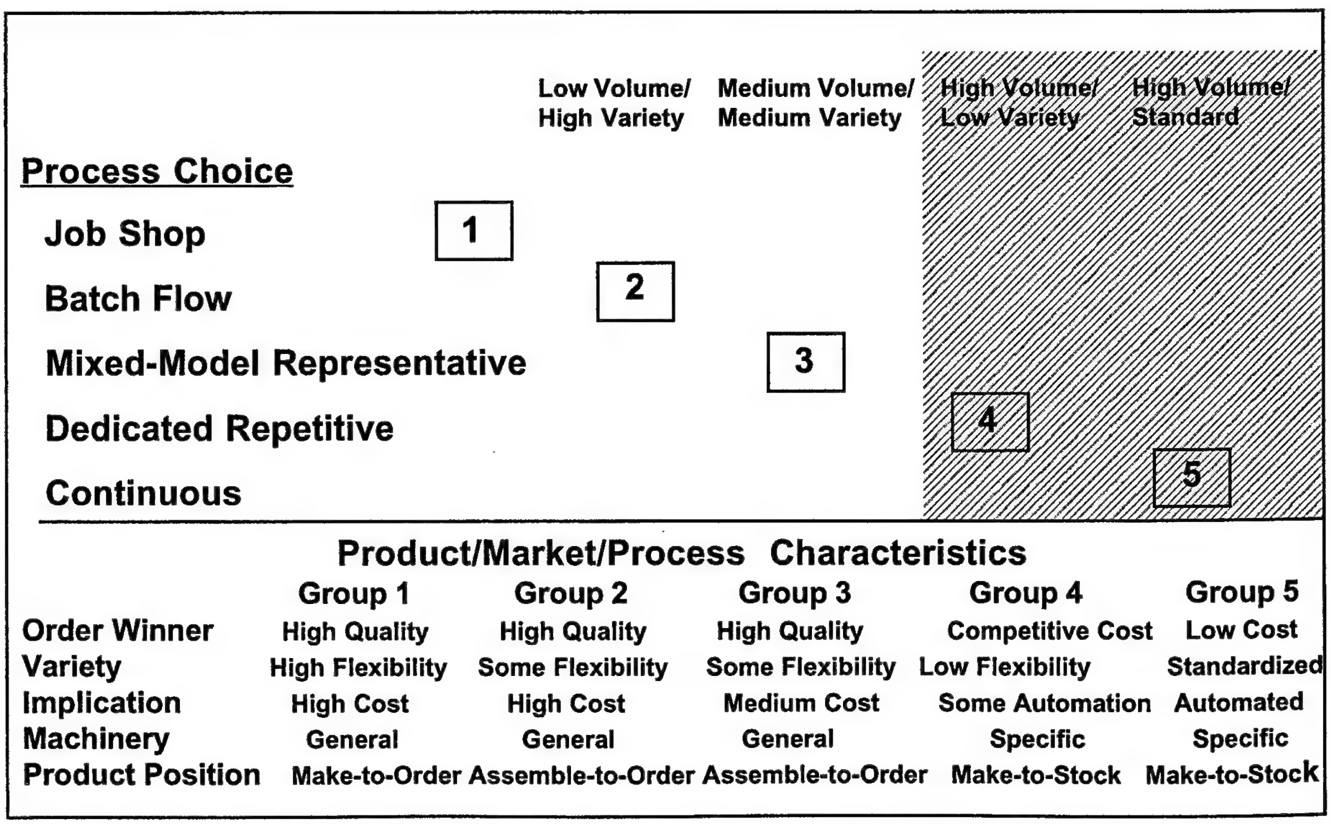


Figure 1. Make-to-Stock Structure

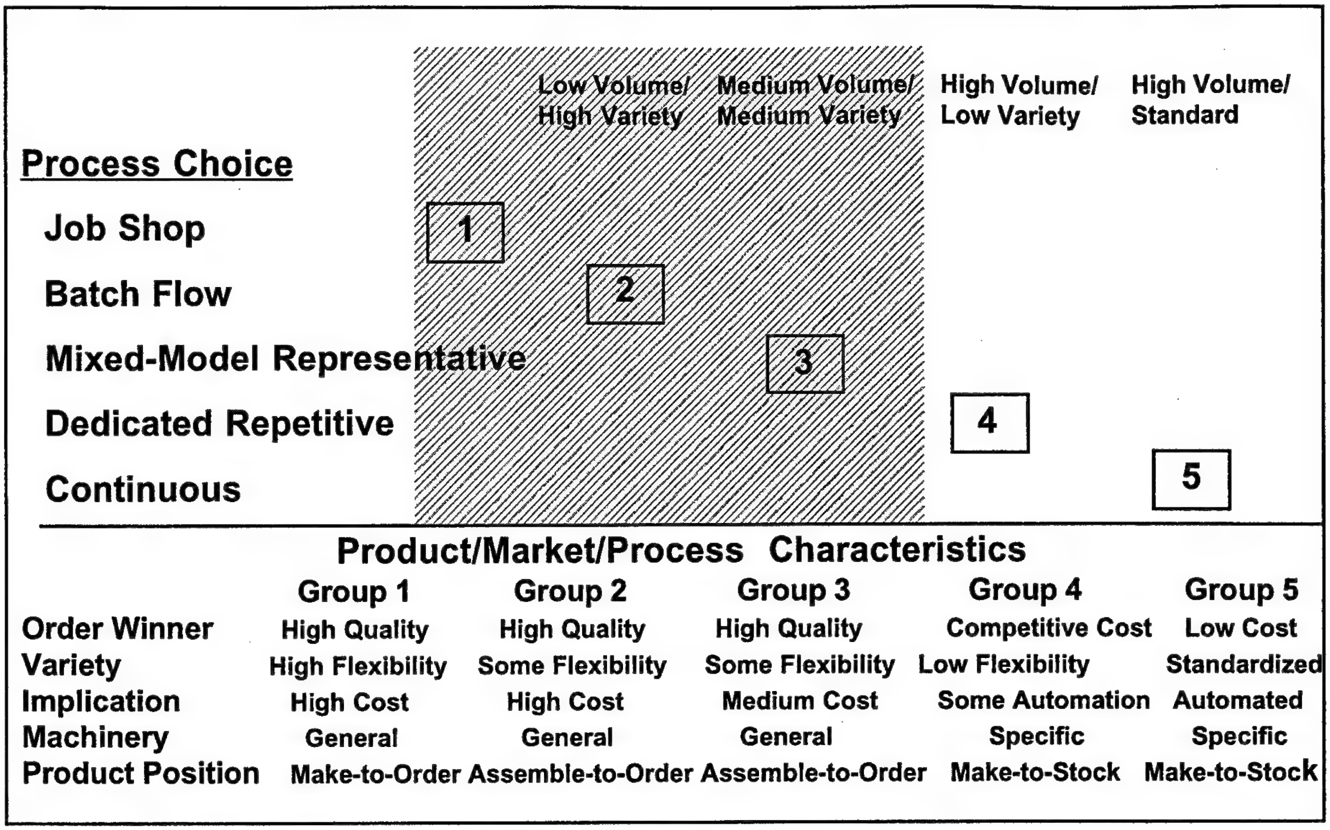


Figure 2. Make-to-Order Structure

perform the repair functions of a reparable-item inventory system for engines and engine components. For simplicity, they will be referred to as the front-shop (whole engine assembly and disassembly) and the back-shop (component repair). The front-shop supports worldwide turbine engine repair. The back-shop has two customers—they provide engine components to the front-shop (engine assembly line) to produce whole-up engines and they provide engine components to the bases that have the ability to remove and replace these components (line replaceable units—LRUs) in the field. The Propulsion Directorate at OC-ALC has been a part of this reparable-item inventory system for turbine engines for more than 40 years, but the pressures to adapt to changing environments, strategies, competitive pressures and economic situations have never been stronger than they are today.

The Initiative—to Be Responsive, Flexible and Precise

Agile Combat Support pushes the Air Force to develop logistics systems that are responsive, flexible and precise. Lean Logistics (now termed Agile Logistics), drawdowns, reduced budgets and other fiscal constraints require the Air Force to reduce infrastructure, maintain smaller numbers of both inventory and personnel and find ways to reduce costs. All these initiatives have a common desired result: to execute the initiative and to achieve the associated benefits—without degrading mission capability.[4] They also have some inherent conflicts when they are simultaneously applied to the depot repair process.

Responsiveness

To our customer, a responsive logistics system will have the parts (engines) needed available at the exact time they are required. In the past, this was accomplished by having ample stocks of parts located at each and every base around the world. In production management terminology, the depot operated as a *make-to-stock* organization (shaded area in Figure 1).[5] Depots supported this *make-to-stock* inventory policy by producing to a quarterly and annual schedule that was developed based on historical usage and flying hour forecasts. This allowed the depot shop floor to operate on a balanced schedule—a modified continuous/repetitive manufacturing process—throughout the year. This balanced schedule was important since the logistics (parts support) and resource (personnel and budget) processes that support the production efforts were also developed to support a balanced schedule.

In 1994, the Air Force developed the Lean Logistics (now Agile Logistics) concept in response to fiscal constraints and force drawdowns. Under this concept, the method to achieve a responsive logistics system changed. Instead of using large stocks of spares to meet the customers needs, the Air Force moved towards shortening the logistics pipeline via fast transport and shorter field and depot processes. This forced the depot to operate more like a *make-to-order*, *assemble-to-order*, (shaded area in Figure 2) or *Just-In-Time* manufacturing organization. The ability of a depot to respond quickly to changing needs in the field had to be developed to support the Lean (now Agile) Logistics and Agile Combat Support initiatives.

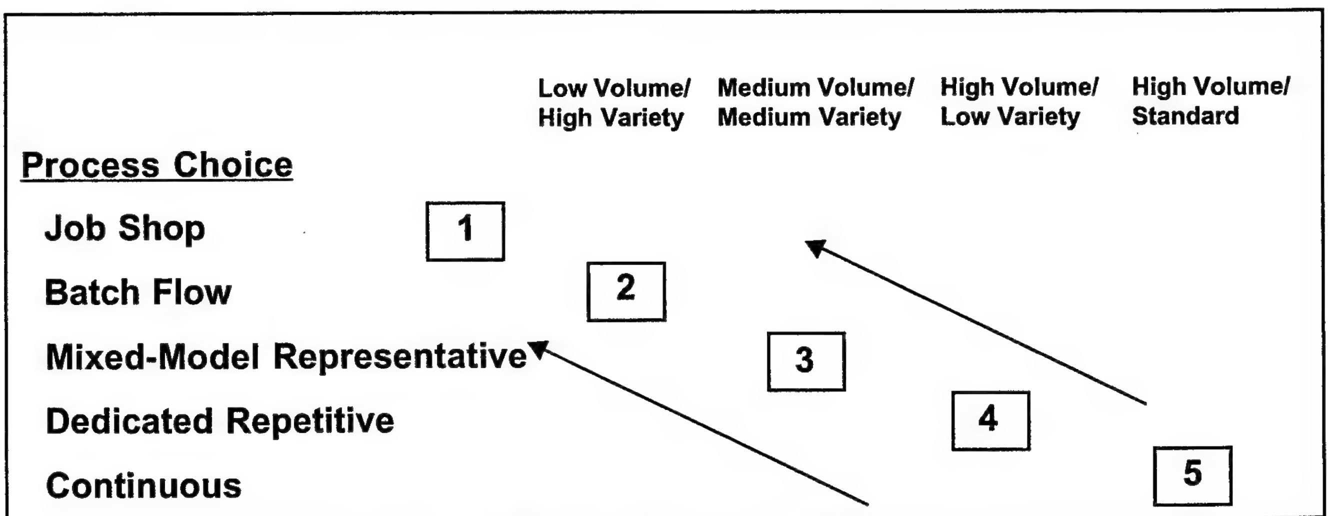
The need to be responsive on the depot shop floor has driven many changes. For example, in the past, an engine or engine

component that was sent to the depot for overhaul would be brought back to a *like-new* condition. In many cases, the depot repair process would repair and/or replace items that did not need to be repaired/replaced. This was inefficient as it wasted parts, manpower and increased depot flow time for both the front-shop and the back-shop. The answer to this inefficiency was to perform a greater amount of *on-condition* maintenance. Under this concept, an engine or engine component entering the depot repair process undergoes a workscope inspection prior to overhaul. This workscope inspection determines the minimum required repairs necessary to return a depot-overhauled engine or engine component with a specified life cycle to the user in the field. The result of this change shortened the flow time for repair of both engines and engine components and allowed the depot to provide more responsive support to the customer.

Another example of change brought about by the need to be responsive is the method and quantity of items brought into the depot for repair. As mentioned before, depot shops in the past produced to both quarterly and annual schedules, with the goal to be as efficient as possible. This created a system where large batch sizes of similar parts were pushed through the repair process at one time—large batch sizes reduced the number of setups required in each shop and returned excellent output numbers per man-hour (efficiency). However, there was no correlation between what was being repaired in the depot and customer needs.[6] The depot was producing according to schedule and its performance metrics were excellent, but it was not responding to the customer. Under the Depot Repair Enhancement Program (DREP), this concept changed. Now, the engine shops at the depot respond directly to customer needs—inducting and repairing individual items according to the greatest need in the field.

At no time in history can the engine and engine component repair process be described as a pure assembly line or continuous/repetitive manufacturing process; however, on a continuum like that shown in Figure 3, the push to a more responsive, flexible system has moved the shop floor process further away from the continuous/repetitive manufacturing system and toward a *job-shop* type environment. A continuous/repetitive manufacturing environment, while generally considered the most efficient form of production, does not respond well to changing requirements. Henry Ford's assembly line is often used as an example of this, where he offered his vehicles in three colors; black, black and black. He did this because of the lack of responsiveness and flexibility inherent in his manufacturing process. A job-shop type environment, on the other hand, is more flexible and can respond to needs for a wide variety of products. However, it is here where a conflict between Agile Combat Support and Agile Logistics appears. Yes, the job-shop environment is more responsive, but it also requires a higher amount of work-in-process inventory to buffer variations in work center loads that are caused by variations in product mix.[7] It is those inventories the original Lean Logistics initiative eliminated. Today, on the shop floor, the reduction in work-in-process inventories along with the rise in unavailability of bit-and-piece parts required to repair engines and engine components is the biggest challenge facing shop managers and depot production.

One of the reasons this lack of inventory is hindering



Product/Market/Process Characteristics

	Group 1	Group 2	Group 3	Group 4	Group 5
Order Winner	High Quality	High Quality	High Quality	Competitive Cost	Low Cost
Variety	High Flexibility	Some Flexibility	Some Flexibility	Low Flexibility	Standardized
Implication	High Cost	High Cost	Medium Cost	Some Automation	Automated
Machinery	General	General	General	Specific	Specific
Product Position	Make-to-Order	Assemble-to-Order	Assemble-to-Order	Make-to-Stock	Make-to-Stock

Figure 3. Item Repair Based on Greatest Needs of Job-Shop Structure

production is because in the past the depot shop floor had excess inventory that masked process problems with ordering, tracking and prioritizing procedures. When the inventory levels declined, the true process problems began to appear. The DREP program is attacking these problems by developing integrated support teams (shop service centers) to effectively manage materiel ordering, tracking and support. It is the shop service center's responsibility, as we move into demand-driven induction for repair, to develop and manage the inventory processes necessary to support production.

Supportability has been hindered by another factor: variability. The push for responsiveness has created higher levels of variation in the process by inducting assets based on customer demand/need as opposed to a balanced quarterly or annual schedule. The push for less waste through increased on-condition maintenance has changed the demand for many parts from being dependent to independent. Where the demand for dependent parts can be determined from its parent item (where an engine always needs the same parts to be rebuilt), independent demand such as repair-type items (on-condition maintenance) can only be forecasted—and mainly by projecting requirements based on historical demand patterns (replacement factors).[8] The increased variability caused by demand-based induction in today's unpredictable world is in direct conflict with an increased reliance on forecasting of independent demand items. To resolve this conflict, a number of initiatives are in work. Supply management policies have changed to shorten resupply times for expendable items managed by the Defense Logistics Agency (DLA). This system parameter design reduces the amount of stock on-hand and replaces it with resupply velocity. It does this by automatically ordering on a one-for-one basis each time an item is issued, which feeds data to DLA that results in better buy practices and shorter resupply times. Other initiatives, such as establishing closer relationships with DLA and other suppliers, reducing acquisition lead times and redefining bench stock (indirect expendable materiel) policies are ongoing to allow production management to find the middle ground between low levels of inventory and the ability to deal with variability in the production process—the solution that will allow production to be responsive to the customers' needs.

. . . manufacturing process must be flexible. The depot shop floor must be able to produce an engine for a F-16 fighter and a KC-135R tanker simultaneously.

Flexibility

To be responsive to the customers' needs, especially in the current environment filled with variability, the manufacturing process must be flexible. The depot shop floor must be able to produce an engine for a F-16 fighter and a KC-135R tanker simultaneously. That will require the back-shops to repair all the reparable components for a single General Electric engine at the same time it is repairing all the reparable components for a single Pratt & Whitney engine. The move toward a job-shop manufacturing environment in itself adds the required flexibility to the manufacturing process through the use of flexible, general purpose equipment that can be used to produce a wide variety of products.[9] Alternate routings through a repair process, multi-skilled employees, shorter setup and repair times, to name a few, are additional methods to improve process flexibility and are central points of focus for engine shop floor managers and process engineers. However, the supporting resource systems must also be flexible to provide support to the manufacturing system.

Manpower resources, for example, must be flexible to allow the manufacturing system to be flexible. Under the depot environment where production was based on quarterly and annual schedules, workload was balanced for the fiscal year. Direct labor personnel levels were determined based on the average level of work on the shop floor for the year (Figure 4). As long as workload stayed constant at the average determined at the beginning of the year, the shop floor had the personnel needed to meet its schedule. Any minor levels of workload variance that required additional output would be handled by the use of overtime. This worked well because it resulted in a smooth level of operation that avoided the costs of changing production levels. A drawback to this is the possibility that inventory would build during low demand periods since the shop was building to schedule, not to customer needs. Or, because the shops had personnel available to do the work and the need to meet efficiency targets, they would continue to produce items that were not needed.[10] Prior to the Lean Logistics initiative, the over-produced parts would go to stock, to meet a future need.

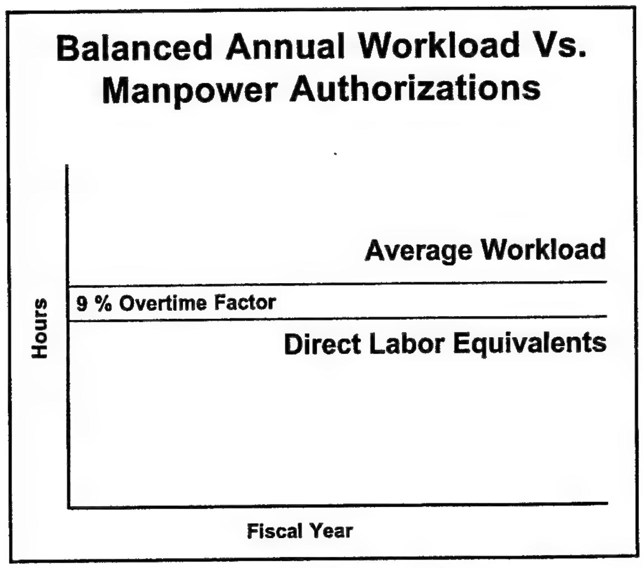


Figure 4. Direct Labor Personnel Levels—Average Workload

Today, personnel levels are still determined based on the average workload for the year. Therefore, any variation in workload (which we have intentionally added to the process to create a responsive organization) creates personnel management problems on the shop floor. The challenge, then, is to meet additional production, when needed, without using excessive overtime labor and to avoid building inventory during periods

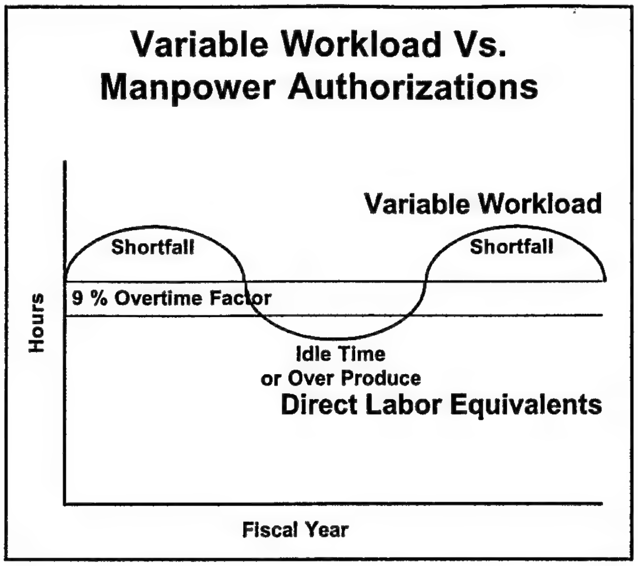


Figure 5. Direct Labor Personnel Levels—Variable Workload

of low customer demand (Figure 5). Clearly, a stable manpower policy does not promote flexibility on the shop floor.

Another problem exists when you combine the following three factors: (1) variability created by demand-based induction of items for repair; (2) the policy of using an average annual workload to determine manpower; and (3) the fact that available shop capacity is approaching required shop capacity (the OC-ALC ratio is 93 percent). This can result in production queuing, climbing work-in-process inventories and poor production output—directly in conflict with the Agile Logistics initiative.[11] The answer: process engineers and workload managers continue to reduce flow days through process improvements, setup reductions and variable repair process routings—freeing up or using existing capacity to its maximum potential. Alternatives for capacity, such as teaming and outsourcing, are being pursued and used when economical to do so.

Precision

From the customer perspective, *precision* from the depot can mean a number of different things. Two important factors from this viewpoint are: (1) meeting the customers' needs on-time and (2) producing a quality product. In both cases, DREP and other changes on the shop floor, to include upgraded information technology systems and quality programs, are being deployed to improve operations to provide this *precision*.

Produce to Need and on Time. As mentioned earlier, the DREP concept was developed, in part, because of the mismatch between depot production and customer requirements. Depot production, to be responsive to the customer, needed a method to identify true customer requirements and a repair policy based on those requirements. Under DREP, these needs were addressed and supported by an automated system called the Execution and Prioritization of Repair Support System (EXPRESS). This system was designed to identify customer needs, prioritize needs for repair and distribution, assess repair supportability and identify constraints and to trigger automatic introduction of reparables into repair.[12] EXPRESS, along with the Air Force's Readiness Based Levels (RBL) program, addressed the proper identification of customer needs and the depot repair of those needs in priority sequence.

EXPRESS is in use on the engine component repair shop floor (back-shop) and has brought improved visibility of customer requirements and their associated priorities. However, EXPRESS does not handle all the complexities of the engine repair process; therefore, it does not provide complete utility to the engine world as it does to the shops in which it was tested/prototyped (avionics). For example, EXPRESS does not provide total visibility for all engine customer requirements. Parts routed to the back-shop from the front-shop, aircraft Programmed Depot Maintenance (PDM)/Standard Depot Level Maintenance (SDLM) requirements and Navy workload are repair requirements that are not visible to EXPRESS. Because of this, shop workload managers have to manually apportion their capacity to support EXPRESS driven and non-EXPRESS driven requirements. Also, these workload managers find the challenge of balancing conflicting priorities between the EXPRESS driven and non-EXPRESS driven requirements (which top-priority item to repair first?). The impact of having two separate systems on the shop floor: increased complexity. Air Force Materiel Command (AFMC) and others are working to resolve these problems by adapting EXPRESS to handle the other requirements or by adapting the other requirements to fit into EXPRESS. Even with this shortfall, however, EXPRESS has improved the visibility of customer needs and provided the induction-on-demand method needed to produce to customer needs.

Once the needs are identified and items are inducted for repair, production management must provide the output on time. The time concept, in today's Just-In-Time environment, adds yet more complexity to the shop floor. Remember, in the past, the engine shops produced to schedule, with the goal of having items sitting on the shelf when they are needed. Metrics focused on output, and the prior management philosophy was *push enough engines and parts in the north end of this building, and I'll get what you need out the south.* This mentality was well suited with the continuous/repetitive manufacturing environment that used to exist. Today, however, the job-shop environment, combined with a constrained pipeline, requires shop floor managers to produce the limited amount of assets in the pipeline on time (induct only on demand, then output per scheduled flow days of repair). Complicated repair routes and the problems with parts supportability further challenge the shop floor managers to provide the required output on time. To measure success, new metrics are being developed that will focus on both input and output and will be detailed to the point of tracking each step in a repair process (queue, setup, run, wait and move times for each step). These new metrics will allow the shop floor managers to more efficiently manage their processes and bring improved *precision* to the shop floor.

To support the new metrics, the Production Branch at OC-ALC is looking at Information Technology (IT) improvements to provide the required information. The Inventory Tracking System (ITS) at OC-ALC has the capability to track and time each

repair part through each part of the repair process. Currently, it is used to track total flow times for repair, but recommended changes to improve usability and the addition of improved input media such as radio-frequency bar code readers will allow shop floor managers to capture data relating to each step in the repair process. These improvements are funded and should be implemented in the near future. In a related IT project, research into shop-floor scheduling tools is underway to fill the gap that exists between the induction process handled by EXPRESS and the subsequent scheduling of flow through the repair process. EXPRESS drives the requirement into the first repair shop in a process. Any subsequent shop that the part flows through, however, is not viewed within EXPRESS for capacity or supportability. When the parts flow through these secondary back-shops, they are handled on a first-in, first-out (FIFO) basis. FIFO, as a scheduling tool, does not perform well in an environment where performance to schedule is important[13]—it is detrimental to the goal of precision. A prototype of a scheduling system built over a simulation of the repair process exists in the avionics arena here at OC-ALC, and it looks like it could be the model for a scheduling system for engine repair. Until an automated system can be made available, managers are looking at policies such as *earliest due date* or a theory of constraints type (drum-buffer-rope) system to use in place of the FIFO system. These tools (improved metrics and a better scheduling policy) are necessary for the shop floor to achieve the needed level of precision to effectively manage the complex engine repair processes.

Quality. If the customer does not receive a quality product, all efforts to produce to need and on time are valueless. Producing a quality product, especially in the turbine engine production arena, has always been of extreme importance—mainly due to engine-related safety-of-flight concerns. Under the Agile Combat Support initiative, quality concepts change in that they must protect the limited quantity of assets in the pipeline. End-item quality has always been important—totally eliminating defects anywhere in the process is the focus for the future. Quality programs are focusing more on repair processes than on just end-item inspections with the intent of designing quality into the product and the process.

At OC-ALC, engine quality has been a success story. Engine component quality, from the customer viewpoint, has met needs for form, fit and function 99 percent of the time. Whole-engines pass end-item inspection at an 88 percent rate, but more importantly, this rate shows a trend of continual improvement over the last three years. Current quality improvement programs and emphasis on foreign object damage prevention are intended to continue the positive trend. Additionally, current quality program efforts include the push to become ISO 9000 compliant. ISO 9000 is an international quality systems standard that provides guidance in the development and implementation of an effective quality management system.

Closing

The changes required on the depot shop floor for Agile Combat Support are significant. We have added a great deal of complexity to the processes and have asked a declining (in numbers) workforce to perform in this new complex environment. In many cases, programs such as DREP and Information Technology improvements have the shop floor moving in the correct direction. These tools, when fully implemented, will help shop floor production managers better deal with the added complexities of Agile Combat Support. In other cases, the shop floor is facing factors beyond its control in its attempt to be responsive, flexible and precise. Other groups, at HQ AFMC and elsewhere, have taken the lead to provide these needed improvements. This article attempted to point out examples of both. Nevertheless, on the shop floor, significant progress is being made. Even in the commercial world, changes to Just-In-Time or other customer-oriented manufacturing environments take a great deal of time to successfully implement—some companies plan this to take six years or longer.[14] Is it worth the time and effort to make these changes on the shop floor? Yes. The depot process, in the engine production arena, has always produced a quality product for its customer and saves a significant amount of taxpayer money. When looking at only seven of the 692 active repairs occurring on the engine shop floor, the ability to repair versus replace saved nearly $8M in Fiscal Year 97. Future improvements, to bolster Agile Combat Support, will produce future savings by providing a more responsive, flexible and precise process by providing high velocity, high quality logistics support to the warfighter and by providing readiness capability should it be needed.

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Major Larvick is currently the Deputy Chief, Production Branch, at the Oklahoma City Air Logistics Center, Tinker AFB, Oklahoma.

Deploying and Sustaining an F-117A Expeditionary Fighter Squadron: Why Agile Combat Support Is Needed Now

Captain Jamie D. Allen, USAF
First Lieutenant M. Brian Bedesem, USAF

The art of war is simple enough. Find out where your enemy is. Get at him as soon as you can. Strike at him as hard as you can and as often as you can, and keep moving on.

—*On the Art of War* by Ulysses S. Grant

Two campaigns fought over 130 years ago decisively influenced the outcome of the Civil War. Both the Vicksburg and Gettysburg campaigns ended the same day, 4 July 1863, with a Union victory. In both, logistics played a decisive role.[1] Today, Commanders in Chief (CINCs) employ their forces knowing that logistics continues to play a decisive role in successfully engaging enemy forces anywhere on the globe, whether they are large military forces or smaller groups of terrorist.

To further develop the inherent capabilities of airpower, we must continue to explore ways to deploy *light* and *lean* as an Air Expeditionary Force (AEF). To this end, initial response and sustainment capability remain key to effectively deploying and employing AEF airpower anywhere in the world. In order to meet this task, logisticians must rely on the principles of Agile Combat Support (ACS) which are, by definition, the cornerstone of Global Engagement and the foundation of the other Air Force core competencies. According to *Global Engagement: A Vision for the 21st Century Air Force*, the Air Force should be able to orchestrate military operations throughout a theater of operations and bring intense firepower to bear over global distances within hours to days. This, by its very existence, gives national leaders unprecedented leverage and therefore advantages.[2] The response and sustainment capability that ACS provides to the Global Engagement concept is what helps distinguish Air and Space Power—speed, flexibility and global perspective.

To maximize the logistical capabilities of ACS, we must focus on the word *Agile*. This fundamental principle of logistics simply means to be mentally quick and resourceful.[3] The challenge to all logisticians, therefore, is to maximize all available resources by learning from our past successes and failures. A Deputy Commander for Maintenance's September 1990 report on lessons learned during his first 30 days of setting up operations in Saudi Arabia showed Agile Combat Support principles would have helped.[4] Forgotten equipment, lack of spare parts and interrupted resupply plagued initial F-16 operations. A strikingly similar report of a maintenance officer's recent deployment to Saudi Arabia with a full squadron of F-15s showed an eerie resemblance of the same need.[5] Despite the efforts of many talented logisticians, several factors, including lack of sustainment capability, drove the mission capable rate below 50 percent after only a month of combat sorties. In addition to these contingency-based lessons, there are also some general logistics lessons learned available in the Air Force Logistics Management Agency report on AEF I-III exercise deployments to Bahrain, Jordan and Qatar during 1995-96.[6]

Efforts should continue to magnify the positive aspects inherent in ACS. Therefore, this article will discuss lessons learned during a recent deployment of F-117As to Kuwait.[7]

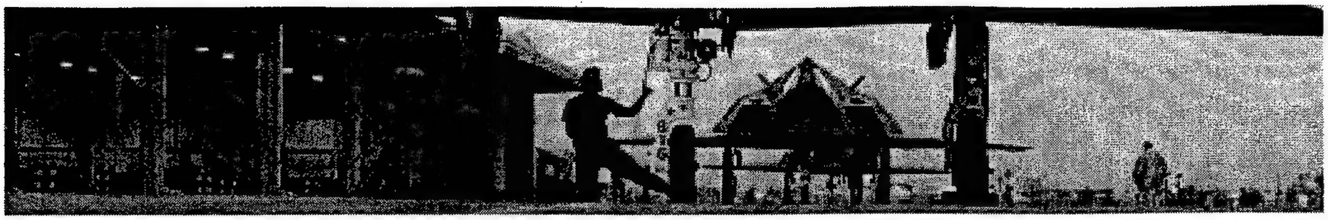
Background

The first large-scale deployment of both F-117A operational squadrons was to Saudi Arabia during Operation DESERT SHIELD/STORM. Afterwards, eight aircraft remained and personnel rotated every three months until all aircraft and personnel returned home in early 1994. The next deployment was September 1996 – March 1997 to Kuwait with eight F-117As in support of Operations DESERT STRIKE and SOUTHERN WATCH. In November 1997, the political situation again worsened in Iraq. Prior to the US Secretary of State and Secretary of Defense flying to allied countries in Southwest Asia to discuss the political and military situation, the 49th Fighter Wing (FW) leadership started preparation for possible deployment of F-117A aircraft, anticipating the need for rapid deployment.

After a week's worth of quiet preparation, wing leadership was faced with the decision whether or not to proceed with a scheduled Phase II exercise the following week. With no definitive answer on the horizon from higher headquarters, the difficult decision to press forward with the needed exercise was made. On the second day of the exercise, with equipment and supplies moved to their exercise deployed locations on base, the real-world deployment orders were received from Headquarters Air Combat Command (HQ ACC). The wing quickly switched from a Phase II exercise to a real-world Phase I deployment. Responsiveness, a pillar of Agile Combat Support, was first to be tested.

Deployment

The 49 FW was tasked to deploy as part of an AEF. This AEF, once deployed, was comprised of the 347th Air Expeditionary Wing (AEW) in Bahrain, the 2nd Air Expeditionary Group (AEG) in Diego Garcia and the 8th



Expeditionary Fighter Squadron (EFS) in Kuwait.

The wing battlestaff met 30 minutes after deployment notification and exercise termination. While operations worked out flight plans and how to build the air bridge of tanker support, unit logistics elements finalized load plans and airlift requirements. An initial meeting of unit representatives at the Deployment Control Center (DCC) immediately after the battlestaff meeting helped confirm airlift requirements. This cross check eliminated several large pieces of equipment that enabled load planners to better utilize airlift. The wing mobility machine was fully operational within hours of terminating the exercise. Equipment was brought back from Phase II operating locations to the units for preparation to deploy. Knowing deployment could come quickly, the deploying fighter squadron commander held a meeting for all deploying personnel that afternoon to solidify the team he would lead as the 8^{th} Expeditionary Fighter Squadron in Kuwait. While cargo was marshaled for final inspection all afternoon and evening, airlift was sourced. Airlift was comprised of one C-141 for the enroute support team (which left at midnight) to Langley AFB and four C-5s and two C-17s. Much to the wing's surprise, all airlift arrived within one day.

By 1800 hours the next day, six F-117As, approximately 290 tons of equipment and supplies and 235 personnel departed for Ahmed Al Jaber AB, Kuwait.

Lesson 1: Utilize Strategic Warning Wisely.

The time between the National Command Authority approving the deployment and deployment notification at the base-level can be hours. By preparing early, all units were able to determine requirements for equipment, supplies and aircraft and to put names to the personnel lists. However, several functional key areas did not have the time to call ahead to the bed-down location to predetermine requirements. They literally worked out some bed-down issues during the flight and during layovers in Europe.

Lesson 2: Conduct One Final Review of Load Plans Prior to Loading Transport Aircraft.

One final review of all load plans was not accomplished. As a result, we took a little more cargo and equipment than needed. When units are tasked for rapid deployment, there is a natural tendency for them to keep adding requirements at the last minute, thus changing airlift and bed-down requirements.

Bed-down

Remember the F-15 maintenance officer who had a difficult time in Saudi Arabia? He expected airlift to deliver his people and equipment on time, in the correct sequence.[8] We both had our cargo delivered in a sequence different than what was planned at home-station. Is this important? Absolutely! For AEFs to be effective, units must reach combat capability as soon as possible in the early stages of the conflict in order to take the advantage.

The first airlift arrived with personnel and equipment at Kuwait City International Airport (KCIA) at daybreak, about 80 hours after receiving the deployment order. Equipment and supplies were then moved, as they arrived, to Ahmed Al Jaber AB, approximately 45 miles away. Holloman AFB transportation personnel and transportation augmentees from Prince Sultan AB worked around-the-clock for three days, ground-hauling the cargo, over 290 tons worth, to Al Jaber with only a handful of 40-foot flatbed trucks because of a country-wide shortage of trucks. The one C-5 that contained most of the critical equipment and supplies needed to reach initial combat capability arrived last.

Lesson 3: Prioritize All Increment Numbers.

Have a plan, prior to leaving home-station, which prioritizes all increment numbers. This enables transportation personnel at the deployed location to deliver the most critical cargo first. The 49 FW has since renumbered all increments by function (for example, fighter squadron, supply squadron, etc.) in order to identify ownership and has tasked each unit to prioritize their increment numbers. The final task is to develop one complete list that prioritizes all cargo delivery during the bed-down phase.

With cargo moving, the deployed First Sergeant worked billeting assignments for personnel as they arrived. The Squadron Commander, Squadron Maintenance Officer and Sortie Generation Flight Chief arrived at KCIA on the first airlift (no advanced echelon—deployed too fast) and were the first to arrive at Al Jaber an hour later. They went directly to the flight line and arrived just as the F-117As were turning off the runway. With much-welcomed help from A-10 *maintainers* from Pope AFB, the aircraft were recovered. Within an hour after arrival, we not only received all needed squadron vehicles but also 12 land mobile radios. The radios were already rekeyed to Al Jaber frequencies by the communication personnel who deployed with us to set up the Wing Initial Communication Package (WICP). With no other personnel and no equipment or supplies, the immediate focus was on:

1. Transporting people and cargo as quickly as possible from KCIA to Al Jaber.
2. In-processing of personnel, assignment of work schedules and developing a recall roster to ensure responsiveness and accountability.
3. Construction of an operations building from scratch. The 8 EFS operations building consisted of three general purpose shelters connected together and completely empty—only external walls, a ceiling and a floor.

Lesson 4: Understand WICP Capability.

Effective bed-down, another key tenet of Agile Combat Support, is dependent on establishing initial communication

capability in the right priority. However, it appears most logisticians have a poor understanding of the capability of a WICP. To remedy this, the 49th Communication Squadron Commander is scheduled to brief the capability of a WICP to all wing logistics officers. This briefing is scheduled for one of the LG-sponsored biweekly meetings of all wing logistics officers as part of the 49 FW Logistics Officers Training Program.

Lesson 5: Don't Always Assume You Will Get All Your Base Support Structure Setup Before You Arrive.

Logisticians cannot always control diplomatic clearances and tanker support. Therefore, your aircraft may arrive before you or as you are starting your bed-down phase.

Sustainment

Once deployed and with the bed-down phase complete, the complex task of sustaining a unique weapon system over 7,000 miles from home-station began. Sourcing and maintaining the necessary supplies on-hand to start immediate combat operations at high sortie rates quickly became a primary focus.

Fuel and Munitions

All equipment and supplies were quickly and completely inventoried to ensure all had arrived and were serviceable. The next step was to ensure enough fuel was on-hand to support initial flying and to support increased combat sortie rates as required by the developing Air Tasking Order (ATO). Also, our munitions crew started inspecting the on-hand ammunition. The Squadron Weapons Officer, working in Operations, coordinated hourly during the first few days with the Munitions Chief to go over what would be needed and what was available.

Reliance on prepositioned assets played a major role in allowing only a short bed-down period prior to becoming fully combat ready. Lieutenant General Hallin, the former Deputy Chief of Staff, Installations and Logistics, at HQ USAF, recently wrote,

> Although one goal of Agile Combat Support is to reduce forward-deployed inventories, even under the AEF concept, these stocks cannot be eliminated. Deploying forces must still rely on some prepositioned assets to spin up deployed forces and begin immediate sustainment, particularly fuel and munitions.[9]

This became very evident, especially while trying to establish and sustain our initial seven to ten days of combat capability.

Lesson 6: Ammunition (AMMO) Stocks Must Be Forward-Deployed.

Forward-deployed assets may or may not be a long distance away, depending on your location. Make sure your AMMO personnel call ahead to understand what the theater CINC's staff is planning. The lead logistician, in this case the deployed senior Aircraft Maintenance/Munitions Officer, must attend daily intelligence briefings to stay on top of the requirements. These intelligence briefings help determine the political and military situation, which in turn can drive sudden changes in the planned types of munitions and the rate of usage.

Safety and Security

The newly developed USAF Operational Risk Management (ORM) program quickly became a valuable friend to us while at Al Jaber. Protection of people and assets were constant issues. Of special note was the 1995 RAND project, *Check Six Begins on the Ground—Responding to the Evolving Ground Threat to U.S. Air Force Bases.*[10] This report, which was published just a year before the ground attack on Khobar Towers at Dhahran AB, convincingly argues that no power in the world seems capable of defeating American air forces in the air. Hence, enemies may have found the most attractive method of defeating American airpower is attacking the sortie generation capability on the ground.

With this in mind, ORM methods were used not only for traditional ground, weapons and flight safety, but to counter a serious terrorist threat.

Unexploded Ordinance (UXOs)

Al Jaber AB is still riddled with UXOs from DESERT STORM. A few soft-surface pathways were cleared, including all of tent city, but most of the unpaved areas on base were off limits. This posed a significant problem to maintenance personnel recovering F-117A drag chutes that blew off the runway after an aircraft landing. After talking through the issues and understanding the risk involved, procedures were established to quickly alert an Explosive Ordinance Disposal team and have them recover the drag chutes. This greatly minimized potential Foreign Object Damage to other aircraft in the pattern and the danger to maintenance personnel during late-night operations.

Net Explosive Weight (NEW) Requirements

When deploying to airfields with limited space in the parking area, a risk assessment must be made to determine the risk involved with certain flight line operations. The risk associated with parking loaded F-117As close together and the subsequent operational capability it provided by freeing up limited ramp space was frequently discussed. Although freeing up additional ramp space was attractive at first, close review of NEW calculations by weapons, ammo, safety and operations experts determined the extra operational capability was not worth the risk to our operation. Decreasing the access of a potential enemy to a concentrated target of loaded aircraft was in our best interest. Several plan options were drafted and presented to on-scene commanders who were ultimately responsible to accept the risks involved.

Lesson 7: ORM Tools Are Needed to Remain Highly Capable.

ACS necessarily includes conducting safe combat logistical operations, which enhances resource availability. Squadron Safety and Security NCOs must develop checklists for use upon arrival at a deployed location, especially for new locations. There is a tendency to run these important programs at home without thought of deployed operations. This point is especially true when less than full squadrons deploy and squadron staff personnel, for example Safety and Security NCOs, stay behind along with their continuity books.

Time-Definite Resupply

ACS also requires a shift from the fundamental way deployed forces are supported through a concept called time-definite resupply. By using the ability to reach back to the Continental United States (CONUS) for supply support and relying on a set delivery time, this type of resupply became critical to the sustainment of our operations because of efforts to conduct a leaner deployment in order to increase airlift availability. Fortunately, significant improvements were made in the mobility footprint of F-117A aviation packages over the last year.

The first small-scale combat deployment of the F-117A was in September 1996 when Iraqi forces threatened United Nations-sanctioned forces deployed in support of the No-Fly Zone. F-117A squadrons, having deployed almost all their aircraft during Operation DESERT STORM, had not pre-planned a smaller aviation package in support of smaller sustained combat deployments. To support the short-notice deployment of eight F-117As to Al Jaber AB, an entire 18-aircraft Mobility Readiness Spares Package (MRSP) was deployed. The MRSP contained *22 pallets* of aircraft spares and supplies. Some of the larger-than-normal size of the MRSP is due to the unique coatings on the aircraft.

During preparations for the November 1997 short-notice deployment of six F-117As, again to Al Jaber AB, a concentrated effort to reduce footprint size was initiated and resulted in deploying only *14 pallets* of MRSP. When six additional aircraft deployed in February 1998, no additional spares were sent.

As a result of an 11-month effort by 49 FW logisticians to reduce the mobility footprint, new requirements were completed in August 1998 for 8 aircraft and 12 aircraft aviation Unit-Type Codes (UTCs). The 18 aircraft aviation UTC was reviewed as well. The result was reducing the equivalent of 6.4 C-141 aircraft required in support of deploying 18 F-117As. In terms of supply support, a significant reduction was achieved by determining only about *ten pallets* of MRSP spares are needed in support of eight aircraft.

Do you see the trend? 22 pallets, 14 pallets, 10 pallets. This well thought-out reduction, however, moved us closer to relying on time-definite resupply because of the lower amounts of deployed spares. We also learned the harder we looked at reducing our mobility footprint, the more we became reliant on a supply and transportation system to deliver on-time.

How Did Time-Definite Resupply Work?

Before deploying to Kuwait in November 1997, the deploying MRSP was transferred to the Air Force Contingency Supply Squadron (AFCSS) at Langley AFB. A Logistics Readiness Center (LRC) was set up at Holloman AFB to help AFCSS with the resupply effort, to include deploying a Logistics Plans Officer to run the LRC effort at Al Jaber. At Al Jaber, we ordered supplies directly through the AFCSS using laptops connected to a base local area network (LAN) in the hangar. AFCSS sourced the items, and they were shipped to us. Sounds easy right? Here is what we encountered. It took base communication personnel almost a week to get the MRSP personnel online with AFCSS in the hangar. They were overwhelmed with activity and encountered connectivity problems. Fortunately, a Standard Base Supply System (SBSS) terminal was available in the A/OA-10 hangar across the flight line to order parts until we were connected with the base LAN. Although Core Automated Maintenance System (CAMS) connectivity with home-station was achieved at about the same time the SBSS link was made to Langley, aircraft parts could not be ordered via CAMS as required at home. CAMS was connected to Holloman AFB, while SBSS was connected to Langley AFB. If a part was ordered via CAMS, Holloman Supply would have received the requisition. Hence, document numbers and status had to be manually updated in CAMS during the 7-month deployment. This was not a *train like you fight* method of doing business. CAMS is not a luxury while deployed, it is a necessity. If aircraft are to be maintained safely and efficiently, current aircraft information must be available during maintenance.

Since high sortie rates were not initially encountered due to postponement of combat operations, parts were consumed out of the MRSP and levels decreased while awaiting resupply. This is where time-definite resupply became a prime focus. Parts were ordered, AFCSS sourced the parts and the Holloman LRC diligently tracked the status of the items in the international pipeline and sent daily updates on every item order. This daily update included from 75-185 items each day that were somewhere in the global pipeline. After quickly working out initial problems with AFCSS, two areas kept our attention:

1. AMC Throughput at Dover AFB. The difference between express carriers and AMC was quite remarkable. The F-117A is somewhat dependent on *ugly cargo* (mostly hazardous, but also some oversized and outsized cargo). Since express carriers were cost-prohibitive to ship hazardous items, AMC got the job. By and large, working Mission Capabilities (MICAPs) was a small part of the sustainment workload. Being proactive to prevent MICAPs, we constantly worked MRSP replenishments, time changes and first-time requisition of items not loaded in the MRSP. The concept of CONUS Reach Back, as outlined in Global Engagement, was top on our list.

Lack of AMC aircraft made deployed sustainment operations challenging. AMC had the right system in place to prioritize movement of cargo. However, the lack of airlift directly impacted efforts to conduct time-definite resupply efforts. AMC normally moves units first, MICAPs second, MRSP replenishment third and Non-MRSP requisitions last. It is expected, though, that deployed units used the right project codes and the correct required delivery dates. Unfortunately, some requisitions were held at Dover AFB awaiting airlift for over three weeks.

Lesson 8: Consider Taking 30 Days of Supplies That Ship as Ugly Cargo.

AEFs may not enjoy the dedicated *Desert Express* transportation service provided by Air Mobility Command during DESERT SHIELD/DESERT STORM. Hence, consider taking 30 days of supplies that ship as ugly cargo. An alternative is to calculate the cost of keeping a 7-day supply on hand and paying the extra cost to ship via express carrier.

2. Returning Reparables to CONUS. Six weeks into the deployment, our Logistics Group Commander (LG) at home-

station discovered all reparables were returning to CONUS only via AMC. When we first arrived at Al Jaber AB, express shipments were being delivered to the flying squadron already there. So it was assumed at least two-level maintenance (2LM) and Lean Logistics (LL)-coded parts were returning via the same mode as well. They were not. Personnel at Al Jaber AB were unaware of previous messages authorizing the use of express shipments from Southwest Asia back to CONUS for all reparables. The Transportation Squadron at Prince Sultan AB, Saudi Arabia, was called and found they were express-shipping only 2LM and LL-coded parts back to CONUS and used AMC for all the other parts. Once initial contact was made for service back to CONUS, it took two months before the contract was in place and express shipments started back to CONUS.

Lesson 9: Work Transportation of Reparable Returns Prior to Deployment.

Before deploying, supply personnel should coordinate with transportation and contracting to determine where the nearest express carrier service is located in relation to the deployed site and whether or not a contract is already established.

Lesson 10: Take an Experienced Supply NCO Dedicated to Managing the Resupply Effort.

The four supply personnel managing the MRSP had their hands full with duties including MRSP replenishment, flight service center, mobility bags and management of M-16 rifles. The lieutenant running the deployed LRC effort was busy with personnel moves in and out of theater, tracking equipment and working load plans for redeployment. In the future, we will take an experienced Supply NCO solely dedicated to tracking the status of all requisitions through the international pipeline. That may sound easy, but it is not, and it is critical to establishing time-definite resupply you can count on.

Recommendations

1. Pursue the development of the Support Options Analysis model recommended by RAND.[11] This model may help deploying units assess, via spreadsheets, the requirements for munitions, POL, support equipment, spare parts, engines, vehicles and shelters prior to deployment.

2. Develop a CONUS site for AEF exercises. This site is needed for combat support exercises to train deployment, bed-down and sustainment of AEFs. It could be used as a main operating base, forward operating location or bare base. The operations community trains using Red Flag exercises, Joint Forces Air Component Commander (JFACC) exercises and Command and Control exercises like the recent Expeditionary Force Experiment 98. The logistics community needs realistic training as well.

3. Change Inspector General criteria on how Operational Readiness Inspections (ORIs) are conducted. Current ORIs do not effectively inspect bed-down and sustainment capability, one of the biggest challenges faced by logisticians. This requires a paradigm shift away from separate Phase I and Phase II exercises. By combining the ORIs, the effect of poor planning and execution will be seen during the bed-down and sustainment phases of the deployment. We should train like we fight.

Conclusion

Many aspects of Agile Combat Support were applied during the recent deployment of F-117As to Kuwait and good results were achieved. The overall mission capability rate for the 7-month deployment was 85.6 percent, 5 percent above the ACC standard—but we still have some work to do.

During the 18-20 August 1998 Agile Logistics Users' Group Meeting, RAND briefed they believe fighter AEF packages can meet a 48-hour bombs-on-target goal to prepared forward-operating locations in Southwest Asia. To make that happen, they estimate tight timelines will be faced and there will be little room for error. Looking back at our last three short-notice F-117A deployments to Kuwait, we agree. However, those constraints must also be applied to the bed-down and sustainment phase of future AEF deployments.

If Ulysses S. Grant was at war with the enemies of today, he would say Agile Combat Support would let us all get at the enemy sooner, strike at him harder and longer and then keep moving on, preferably home.

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Captain Allen was the Squadron Maintenance Officer in the 8th Fighter Squadron. While deployed, he was the Squadron Maintenance Officer in the 8th Expeditionary Fighter Squadron. He is now a Supply Officer in the 49th Supply Squadron. First Lieutenant Bedesem was a Logistics Plans Officer in the 49th Logistics Support Squadron. While deployed, he was the Deployed Logistics Officer in the 8th Expeditionary Fighter Squadron. He is now serving as a wing-level Logistics Plans Officer.

Air Force Logistics Management Agency (AFLMA) Fiscal Year 1999 (FY99) Program

Abstracts for all currently active projects are listed below and on subsequent pages. Please feel free to contact the project manager if you are interested in any of them. DSN access is 596-XXXX; commercial access is (334) 416-XXXX.

Maintenance

Concept of Operations for the Integrated Maintenance Data System (IMDS)
LM199711300—Consulting Project

Describes the relationships between the IMDS Concept of Operations and the Logistics Command and Control (C^2) Concept of Operations.

Capt Chris Melcher, AFLMA/LGM, 596-4581

Quality Assurance Tracking and Trend Analysis System Y2K Replacement
LM1998134400—Consulting Project

1. Evaluates Air Force *home-grown* and commercial quality assurance programs.
2. Produces a list of recommended replacement options.
3. Determines the amount of AFLMA programming resources that must be expended to bring replacement options up to Air Force standards.

MSgt Maura Barton, 596-4581

Development of Interactive CD-ROM Program for Logistics Group and Wing Commanders—Munitions Operations
LM199815900—Improvement Study

1. Develops a CD-ROM to familiarize group and wing commanders with munitions operations as part of Agile Combat Support.
2. This project addresses:
   a. Munitions inspections.
   b. Mission impacts.
   c. Officer/NCO roles.
   d. Explosive siting.
   e. Security requirments.
   f. Nuclear surety.
   g. Hyperlinks to munitions information.

Capt John E. Bell, 596-4581

Flight Safety Critical Aircraft Parts (FSCAP)
LM199731300—Improvement Study

1. Identifies the various cost components involved with identifying FSCAPs.
2. Identifies the difficulties involved with tracking FSCAPs.

Maj Dorothy J. Tribble, 596-4581

Consolidation of Egress Time Change Items (TCI)
LM199827900—Improvement Study

1. Determines the spares cost per aircraft to implement a fixed 42-month Egress TCI cycle.
2. Determines the reduction, and if possible, cost savings for both maintenance events and aircraft downtime.
3. Evaluates the impact of a revised scheduled maintenance interval on aircraft availability and expeditionary airpower deployment operations.

MSgt Maura Barton, 596-4581

Supply

Secondary Inventory Control Activity (SICA) Non-Consumable Item Materiel Support Code (NIMSC 5) Process Analysis
LS199531800—Improvement Study

1. Describes the Primary/Secondary Inventory Control Activity (PICA/SICA) process.
2. Analyzes the effectiveness of the process.
3. Develops process improvements for any identified deficiencies.

Ms. Diane Stradone, 596-4165

Initial Spares Support List (ISSL) Process Review
LS199718900—Improvement Study

Analyzes the initial provisioning process to determine:

1. What failure data is computed?
2. What computational methodology to use with demand data—either estimated or actual?
3. How to ensure levels sent to bases match the D041 computed requirement?
4. How should assets without demand data be handled?
5. What should be done to ensure ISSL levels already loaded match the D041 requirement?
6. Should Readiness Based Leveling (RBL) treat ISSLs any differently than other Adjusted Stock Levels (ASLs)?

1st Lt David A. Spencer, 596-4165

XB3 Items with a Positive Demand Level and a Re-Order Point of Zero
LS199718901—Improvement Study

1. Determines the number and mission impact of items with a reorder point of zero.
2. Compares the cost to increase the reorder point to the benefit of reduced backorders.

MSgt Woodrow Parrish, 596-4165

Aerospace Maintenance and Regeneration Center (AMARC) Supply Study
LS199726900—Improvement Study

1. Determines the most appropriate supply computer support concept for AMARC/LGS—whether a host or satellite account off of the Davis-Monthan supply account.
2. If possible, quantifies increased sales of AMARC *hidden inventory* parts to meet Air Force Mission Capable (MICAP) requirements.

The Agency conducts three kinds of study and analysis efforts:

1. Logistics Improvement Studies. These studies target specific problems, issues or questions; improve existing processes; develop new processes or programs; develop prototype software; and develop and create training and job aids (handbooks, users manuals or guides).

2. Consulting Studies. These efforts focus on monitoring an activity or acting in an advisory capacity.

3. Requirements Team Studies (Supply only). These focus directly on improving the systems used to manage Air Force spares.

3. Determines the most appropriate way to improve visibilty of *assembled parts in storage* (D003A) data.

MSgt Bernard N. Smith, 596-4165

Execution and Prioritization of Repair Support System (EXPRESS) and Primary Aircraft Authorization (PAA) Study
LS199801500—Improvement Study

1. Evaluates how program logic in EXPRESS treats bases with dissimiliar Primary Aircraft Authorizations (PAAs) (small versus large PAA).
2. Compares EXPRESS prioritization sort value results for unique versus common assets.
3. Identifies depot repair policies and execution procedures, including funding aspects, which impact Special Operations Forces (SOF) repair prioritization/distribution.
4. Compares actual asset distributions to SOF and common C-130 units since EXPRESS was implemented.

Maj Brian Trigg, 596-4165

Luke F-16 Training Wing Study Revisited
LS199802700—Improvement Study

1. Conducts a follow-up analysis of the *F-16 Training Wing Issue Effectiveness* (LS9534600) study.
2. Compares/contrasts AETC supply effectiveness indicators for the Luke AFB F-16 Training Wing (Non-Readiness Spares Package [Non-RSP]) with Air Combat Command F-16 bases (with Readiness Spares Package [RSP]).
3. Identifies projected trends impacts for Non-RSP and RSP units
4. Identifies Execution and Prioritization of Repair Support System (EXPRESS) or Readiness Based Leveling (RBL) implementation issues which might impact or negate additive requirements from before/after trend analysis, the redistribution review and the RBL capping review.

1st Lt Jennifer Manship, 596-4165

Performance Metrics for the Readiness Based Leveling (RBL) and the Redistribution Order (RDO) Process
LS199805700—Improvement Study

1. Reviews and updates the Air Force Supply Executive Board (SEB)-approved performance measurements (metrics) designed to identify and correct deficiencies in the RBL and the RDO process.
2. Determines the best method to collect RBL and RDO performance data. This will include:
   a. Source of the data for each metric.
   b. Who collects the data.
   c. How to collect the data.
   d. When to collect the data.
   e. How to identify, screen and correct suspect data.
3. Develops and proposes policy and procedures that address:
   a. Who reports the metric.
   b. Who reviews the metric.
   c. When to recommend systemic changes to improve performance.

MSgt Robert A. Nicholson, 596-4165

Analysis of E-3 Support Concepts
LS199806400—Improvement Study

Examines current concepts for E-3 support:

1. Are the existing Readiness Spares Packages (RSPs) and Peacetime Operating Stock (POS) levels adequate?
2. What impact do long pipelines into deployed locations have on support?
3. How does the prioritization of E-3 components in the Execution and Prioritization of Repair Support System (EXPRESS) affect support?

Capt James A. Neice, 596-4165

Volatility of Readiness Based Levels
LS199826400—Requirements Team Study

1. Determines the amount of variability in pushed levels. If the variability in levels is significant, develop and recommend solutions to the problem.
2. Determines the ideal frequency of RBL runs per year.

1st Lt David A. Spencer, 596-4165

Fuels and Engineering IPT
LS199826600—Consulting Project

Improves fuels management processes: cost-effectiveness and readiness.

SMSgt Larry C. Ransburgh, 596-4165

Monthly Standard Base Supply System (SBSS) Local Purchase Activity Analysis
LS199826800—Consulting Project

Provides a monthly report of all local purchase item records in the SBSS with a dollar value below $2.5K. This report identifies:

1. Specific supply account(s).
2. Number of records.
3. Number of records with demand or special levels.
4. Total number of requisitions.

MSgt Robert A. Nicholson, 596-4165

AMC's Enroute Requirements—How to Include in the Air Force's Centralized Computation
LS199719900—Improvement Study

1. Determines if a *new* leveling policy should be developed and how to incorporate it into requirements systems.
2. Develops and tests procedures and programs.

Capt James A. Neice, 596-4165

Contracting

Contractor Operated Parts Stores (COPARS) Tools and Guide
LC199719000—Improvement Study

1. Publishes a COPARS guide addressing: the program's background, contracting and transportation processes, roles and responsibilities, pricing/ordering/contract changes, policy, acquisition planning, program management and administration, best practices and keys to success.
2. Includes an interactive quiz based on the information included in the guide and a template Performance Work Statement (PWS). The guide will also be distributed in a help file format.

SMSgt Jose R. Medina, 596-4085

Contracting Squadron Training Plan (Update)
LC199823205—Improvement Study

1. Enhances the knowledge and professionalism of the Air Force contracting work force by updating the Air Force Contracting Squadron Training Plan.
2. Provides training resources and references in a World Wide Web-based format with direct links to the materials for training.

MSgt Lisa Rogers, 596-4085

Standard Contracting Customer Education Guide
LC199827102—Improvement Study

1. Develops a document to present organized/standardized training.
2. Eliminates confusion in the field and expedites the acquisition process.
3. Improves the quality of acquisition processes and increases customer satisfaction.

SMSgt Jose R. Medina, 596-4085

Commanders' Guide to Operational Contracting
LC199831803—Improvement Study

Provides wing and group commanders with a multimedia-based operational contracting guide. It includes the following modules:

1. Competitive sourcing and privatization.
2. The Government credit card.
3. Socioeconomic programs.
4. Quality assurance and contract performance.
5. Contracting authority.
6. Other contracting information.

1st Lt Judson Bishop, 596-4085

Transportation

Upgrade Vehicle Replacement Model
LT199827600—Improvement Study

1. Upgrades the Vehicle Replacement Model. The upgrade makes the model more user friendly to operate, adds additional utilization factors (miles/hours) to the economic life expectancies determination and computes wasted dollar values for retaining vehicles beyond economic life.
2. Identifies wasted dollars if vehicles are disposed of prior to the suggested replacement point.
3. Assesses Year 2000 (Y2K) compliance.

Capt Patrick K. Pezoulas, 596-4464

Civil Air Patrol (CAP) Aircraft and Vehicle Fleets Study
LT199824400—Improvement Study

Determines the appropriate CAP aircraft and vehicle fleet size to support:

1. Air Force assigned and reimbursable missions.
2. Air Force assigned and non-reimbursable missions.
3. All other CAP corporate missions.

Capt Patrick K. Pezoulas, 596-4464

Logistics Plans

War Reserve Materiel (WRM) Analysis/WRM Prepositioning Tiger Team
LX199722700—Improvement Study

1. Establishes a schedule for future meetings and reviews current War Plans Additive Requirements reports (WPARR) and War Consumables Distribution Objective (WCDO) to determine starter stock requirements.
2. Reviews PACAF Area of Responsibility (AOR) requirements documents versus actual swing and starter stock requirements. Reevaluates current AOR prepositioning based on the two Major Theater War (MTW) scenario, with a goal of attaining the ability to support the full spectrum of military operations to include small scale contingencies and air expeditionary forces. Recommends WRM allocation options based upon the starter stock definitions and determines what could be used as swing stock for prepositioning options.
3. Same as # 2 for the Central Command Air Forces (CENTAF) AOR.
4. Evaluates prepositioning options suggested from the third and fourth meetings based upon:
    a. Risk.
    b. Cost benefit analysis.
    c. Accessibility.
    d. Timelines.
    e. Capabilities.
5. Consolidates final inputs for presentation to the Air Force WRM Executive Review Board (AFWERB).

Capt Paul Boley, 596-3535

Logistic's Readiness Center (LRC) Baseline
LX199726600—Improvement Study

1. Determines a concept of operations for LRCs supporting expeditionary forces.
2. Determines LRC interfaces at different levels and with different organizations. Establishes guidance for roles and responsibilities at each level.
3. Determines system requirements.
4. Determines functional roles, responsibilities and training requirements.
5. Identifies needed improvements in modeling and simulation, exercises/wargames, contingency support, systems support and operations/joint logistics interfaces.

Capt Donald E. Cohen, 596-3535

GLOBAL ENGAGEMENT 98
LX199808200—Improvement Study

1. In conjunction with HQ USAF/ILXX and the Wargaming Institute, this project develops logistics objectives and play scenarios for GLOBAL ENGANGEMENT

98. Both the objectives and play scenarios highlight the following Agile Combat Support tenets:

a. Responsiveness.

b. Survivability.

c. Sustainability.

2. Demonstrates Agile Combat Support tenets via real-time decision support for:

a. Force allocation and basing.

b. Reception and bed-down.

c. Sustafinment.

3. Illustrates the effect Weapons of Mass Destruction (WMD) have on:

a. Support capabilities at bed-down locations.

b. The sustainment pipeline.

4. Provide feedback that specifically addresses mobility, AFMC capabilities and pipeline choke points. Also provides feedback which covers:

a. Sustaining operations.

b. Retrograde.

c. *Reachback.*

d. *Time-definite* delivery.

Capt Maria L. Garcia, 596-3535

21G Pamphlet

LX199833500—Improvement Study

Develops a brochure/pamphlet to market the Logistics Plans Officer career field to officer candidates.

MSgt Dale H. Watkins, 596-3535

Logistics Officer Career Handbook

LX199833501—Improvement Study

1. Develops a logistics officer handbook that outlines career opportunities, education and training and potential career paths open to logistics officers across all 21XX AFSCs.

2. Explains cross-functional matters to logistics officers including the crossflow program, career broadening, joint service opportunities and any other non-traditional opportunities for logisticians.

3. Cross-references joint, Professional Continuing Education (PCE), Professional Military Education (PME) and specialty courses open to officers including descriptions and target audiences.

Capt Maria L. Garcia, 596-3535

Survey of Legacy and Future Logistics Modeling and Simulation (M&S) Systems

LX199830100—Improvement Study

1. Conducts a survey of all current logistics models and tools; determines the *best of breed.*

2. Groups models and tools into *toolkits* which meet the M&S analysis, training and acquisition objectives.

3. Ensures logistics requirements are included in major future M&S efforts: National Air and Space Model(NASM)/Joint Simulation System (JSS), Joint Warfare System (JWS) and Joint Modeling and Simulation System (JMSS).

4. Gathers M&S requirements.

5. Provides requirements to model developers in a usable format.

Capt Patrick Walker, 596-3535

Measuring the Effect of RFID Technology on Movement of US Army Resupply Cargo continued from page 13)

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36. Adapted from *DoD 4140.1-R*, May 98.
37. A Transportation Control Number (TCN) is a unique 17-position alphanumeric data element assigned to control a shipment unit throughout the transportation pipeline. A Lead TCN represents a set of individual shipment TCNs consolidated—physically and systemically—under a single TCN for ease of movement and ITV throughout the DTS.
38. The RF/ITV query screen is located at http://144.170.190.8/ITV_summary.html
39. A DoDAAC is a six position alphanumeric code identifying specific activities authorized to ship or receive materiel and prepare documentation or billings (DoD, 1987: A-4).
40. Shipments were removed from the sample population for only two reasons: the time sequence of events was out of order or the transit time for a particular mission leg fell outside the selected range. Thus, shipments were not eliminated as outliers based on Port Hold Time (PHT).

Captain Method is currently a Project Manager assigned to the Transportation Division at the Air Force Logistics Management Agency, Maxwell Air Force Base, Gunter Annex, Alabama.

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should prevent inaccurate data reporting and enhance the decision-making process of all agencies involved.

The importance of accurately reporting data can not be underestimated. Incorrect receipt dates could adversely affect the use of commercial freight carriers (air and motor) because faulty information could improperly indicate a carrier's true performance. If shipment data indicate late deliveries, the Traffic Management Office may request a period of probation or non-use for that carrier.

Conclusions

Bottlenecks exist within the LRP Air Force-wide, based upon the supporting data from the ETADS. Over 80 percent of the 768 shipments evaluated did not meet the UMMIPS standard. When divided by theater of operation, bottlenecks exist within multiple segments of the pipeline. These segments are the AE (Item Availability) and AS (Shipment Status). The most prominent location is the AS segment with 49 shipments exceeding the UMMIPS standard by more than one day.

Based on careful evaluation of the processes, a significant factor resulting in bottlenecks is improper shipment planning. It is critical to verify information on the IRRD such as the SRAN/DoDAAC. If a shipment is misdirected it will result in a serious delay within the order-cycle and logistics pipeline and result in increased transportation costs.

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Captain Pezoulas is currently a Project Manager assigned to the Transportation Division at the Air Force Logistics Management Agency, Maxwell Air Force Base, Gunter Annex, Alabama. Captain Muno is currently a Transportation Officer's Course Instructor with the 345th Training Squadron, Lackland AFB, Texas.

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Lieutenant Colonel Bell is currently the Director of Advanced Programs at the Armament Product Directorate at Eglin AFB, Florida.